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THE NUMBER OF SPIRAL NEBULAE.

By H. C. WILSON.

The first part of Volume 13 of the Publications of Lick Observatory* contains a list of 762 nebulæ and clusters which have been photographed with the Crossley Reflector by Astronomer H. D. Curtis. The positions of these nebulæ are tabulated according to right ascension and declination, with a brief but rather complete description of each, so that the table itself makes interesting reading.

Accompanying the table are two plates, one of which we have reproduced in two parts for this number of POPULAR ASTRONOMY. In our Plate IX are shown four photographs of a new type of spiral, which Dr. Curtis designates the ϕ-type. Dr. Curtis says that there are 23 examples included in his list, so that it is a fairly common type of spiral. "Its main characteristic is a band of matter extending diametrally across the nucleus, and inner parts of the spiral. Frequently the whorls in this type form a nearly perfect ring; in other examples, the whorls appear to begin at the ends of this cross-arm. The general appearance is that of the Greek letter ϕ, and I have termed such objects ϕ-type spirals for the lack of a better name".

Out of the 762 nebulae listed in the table, 513 are described as "spiral"; 56 as "diffuse nebulosities"; 36 as "globular clusters"; 24 as "sparse clusters"; 78 as "planetary nebulae"; and 8 as "dark nebulae". Forty-seven are unclassified, some of them possibly non-existent. Many of the nebulae are exceedingly small, so that the exact form could not be determined, but Dr. Curtis says, "It is my belief that all the many thousands of nebulae not definitely to be classed as diffuse or planetary are true spirals, and that the very minute spiral nebulae appear as textureless discs or ovals solely because of their small size".

Dr. Curtis gives a careful discussion of the probable number of spiral nebulae to be found in the whole heavens, based upon the photographs which have been taken with the Crossley Reflector, and reaches the

* Publications of the Lick Observatory Vol XIII, University of California Press, Berkeley, 1918.

The 513 listed spirals added to this number make the total 6,211. The one million. Careful counts were made on plates covering 439 regions of the sky. These gave a total of 5,698 small uncatalogued nebulae. The 513 listed spirals added to this number makes the total 6,211. The exposed area of a Crossley plate is about 9/10 of a square degree, but the edges and corners of this area are poorly defined, owing to the distance from the optical axis of the reflector, so that only the brighter small nebulae can be picked up in these portions of the plate. The majority of small nebulae are found in the more central portions of an area of 6/10 of a square degree, or less. Dr. Curtis assumed 0.75 of a square degree as the average effective area on which the counts were made. He says, "This is certainly somewhat in excess but is in error on the conservative side". The total area of the 439 regions would thus be 329.25 square degrees. If the regions were uniformly distributed over the sky and the proportion shown by these regions should hold generally, the number of spiral nebulae in the whole sky would come out about 778,000. Because of the well-known fact that the brighter spiral nebulæ appear to be grouped in greater numbers near the poles of the Galaxy, Dr. Curtis has studied the effect of the unequal distribution of the plates in various regions of the sky. He finds that the small nebulae also show concentration in the galactic polar regions.

The following table shows the results which he has obtained from counts of the nebulae in the regions within 45 degrees of each pole; 30 degrees on each side of the galactic equator; and in the 15 degrees on each side of the equatorial zone. It will be seen that there is considerable difference in the numbers found in the different zones, but that the total for the whole sky still comes out over 700,000.

The greatest number of nebulæ found on a single plate was 304. This was checked by a duplicate plate. The central portion of this remarkable region is reproduced in Plate X. Most of the nebulæ are so small that they are not recognizable to the naked eye in the engraving, so that a circle has been drawn around each one to call attention to them.

Galactic Latitude	No. of Regions	Square Degrees	No. of Spirals	No. per Sq. Degree	No. in Area
$+45°$ to $+90°$	117	88.50	2,997	34	205,000
-45 to -90	43	32.25	918	28	169,000
± 30 to ± 45	62	46.50	1,117	24	204,000
-30 to $+30$	217	162.75	1,179	7	144,000
Totals	439		6,211		722,000

FIRST STUDY OF HEAVENLY BODIES.

By MARY E. BYRD.

Lesson IV.

The usual astronomical predictions given each year in the American Ephemeris include no striking phenomena for April, 1920. It is not the month of an equinox or solstice nor one with an eclipse of sun or moon. But April is so short a month, it would seem that without unwarranted poaching on the preserves of May, we might appropriate the total lunar eclipse that comes when that month is not yet two days old!

It would indeed be too late, in the next lesson, to give suggestions for observing the eclipse, and it deserves attention in spite of the fact that its scientific value is rated very low by astronomers. For them it may almost be said there is only one eclipse, a total eclipse of the sun. For that they will journey to the uttermost parts of the earth, risking hardships and injury to health. And totality lasts only a few minutes, rarely more than four or five. In a word, a total solar eclipse is a tragedy, while a lunar eclipse, in good, old Shakespearian diction, is a comedy. Much about it is "As You Like It." It presents so many points of interest to the elementary student that there is room for choice, it lasts so long that there is abundant time to write full notes and make careful sketches, it is free from nerve-racking strain, but possesses the dramatic element and easily holds attention to the end.

The eclipse in which, at present, our interest centers occurs under favorable conditions. In May, fair weather is probable, it is a comfortable month to observe out in the open, the moon "runs low" so there is no need to fear a stiff neck, and the duration of totality, a little more than an hour, is even more satisfactory than the longer periods. The whole phenomenon comes in convenient hours, at least for the northeastern section of the country, as the moon enters the earth's shadow at 7 P. M., E. S. T., and passes out a little before 11 P. M., according to the same time. The farther west we go, the earlier of course come the beginning and ending, and when the moon rises to dwellers on the Pacific coast, the eclipse is mainly a thing of the past.

Owing to the varying circumstances of the eclipse, no set of topics can be prepared that fits all sections, yet this is hardly a drawback. It is no small advantage for beginners to learn how to adapt a general outline to local conditions and to amplify it by a number of details thought out for themselves. Whatever scheme is employed it can hardly fail to insure valuable training in seeing and recording. It ought

not, however, to be too strenuous and crowd out the pleasure of the spectacle. To find out, to know, to enjoy, all of right belong to the first study of heavenly bodies.

The moon eclipsed or uneclipsed, every object that moves on the celestial sphere from a meteor to the sun itself, has its place fixed by reference to the stars, and thus it is that a thorough knowledge of the constellations is a pressing necessity.

The initial steps already outlined are study of star-maps, finding prominent constellations in the sky, and identifying individual stars; and, though it may sound unscientific, I would add making friends with the stars. They should not be looked upon merely as objects for investigation, but as the revealers of pleasing mysteries, guides in the realm of exploration and adventure. The times for watching them should not be confined to fixed periods. Whenever we pass beyond the prison walls of houses, the sky should draw our eyes like a magnet. Unusual hours, early in the morning and late at night are particularly favorable, for then perchance we may surprise familiar constellations and well-known planets in new positions with regard to horizon and meridian, and then too may come the long-sought opportunity to answer some question on our own special list.

Almost any place where the heavens are visible is a good observing station. At Hunter College, in New York City, students of mine often utilized fire escapes and the flat roofs of buildings, and one at Smith College, I remember, obtained an excellent record of the waning light of Algol by watching it at different railway stations, on an evening trip from Northampton to Ashfield. Those who often look up and join thinking to looking will, from the testimony of their own eyes, become reasonably certain of several things: that the constellations follow night after night the same line of march and keep the same formation, Gemini always east of Taurus, Virgo east of Leo, and that every one maintains its own star grouping. The belt and sword of Orion remain in place and there is no change in the jewels of the Northern Crown.

When, in ways like these, the face of the sky has become familiar and a number of constellations are known by marked configurations, there is no better method to employ in gaining more exact knowledge than making our own maps of the constellations. The first one may seem a poor thing; that it is "mine own" means much. Let us then undertake a map of Gemini, already recognized by the twin stars, Castor and Pollux. In identifying others that are to be included, the following steps are suggested:

Pass a line through the α's of Orion and Gemini, and the brightest star on the line, removed from α Orionis rather more than 2/5 of the distance between the two, is γ in Gemini. With this star identified and Castor and Pollux known, there is no need of further reference to Orion and the stars hereafter mentioned belong to Gemini. The line

through γ, just found, extended to Pollux, i. e., β, passes close to ζ and δ, though both, especially δ, are set off a little in the direction of Procyon. The two should not be confused for δ is roughly midway between β and γ but ζ is decidedly nearer the latter.

By means of these stars, γ and ζ, μ is located, for it makes with them an isosceles triangle, approximately right-angled at γ. The star ϵ is the one on the line joining μ and α, at 1/3 the distance between them from μ. From these five stars, others are found if desired and a check for the whole identification is obtained by noting that, if $\gamma\mu$ were shortened a little at the γ end, α, β, γ, μ would form a fair parallelogram with the long side some four times as long as $\alpha\beta$.

In such an exercise as this star-maps are constantly consulted, for the object in view is to make sure that the stars in the sky called γ, δ, μ, for example, are the ones marked by these letters on the maps. These, however, should be laid aside when the more important stage is reached and drawing begins, certainly reference should not be made to them in fixing star places. It is the sky, not the map that is to be copied. The latter too may prove a false guide for it represents so large a portion of the heavens on one page that more distortion is to be expected than in dealing with a single constellation.

In drawing maps it is a good rule to make haste slowly. Take a little time to become acquainted with the general appearance of the constellation and the grouping of its principal stars. Thus, for Gemini, fix in mind a clear picture of the long, narrow quadrilateral, noting how the length and slant of its sides make it just miss being a parallelogram. Decide beforehand what stars to include besides the leaders, Castor and Pollux. The order in which the stars are placed, angles and star-lines also require some attention, for it is evident that right angles and those of 45 degrees are more easily estimated than others and that lines are especially serviceable when 1/2 or 1/3 their length, or that taken 2 or 3 times just fits the distance to be measured. The scale of the map drawn should be much larger than for printed maps, three or four times greater than that of Young's Uranography, and the stars during observation should be designated simply by dots. Later, in the daytime, the proper symbols for magnitude are readily inserted.

Various methods have been devised for drawing constellations. The one illustrated by the following observation has, perhaps, some points in its favor. It is convenient to have the data on which the map is based given in concise form by estimates of angle and distance, and it is an advantage to insure at the beginning the right scale and symmetrical location by a reference line like $\alpha\pi$ in Argo Navis. This is obtained by a card pattern, that is a stiff piece of cardboard that fits exactly two sides of the record page, the other part being cut in such shape that dots marked on its edge bring two leading stars at the desired points on the page. That the map accom-

panying the observation was taken a number of years ago in no way invalidates it for present reference, since the historic groupings of the stars remain practically unchanged.

Observation.—519 Oakland Avenue, Pasadena, Calif., Tuesday, Oct. 27, 1908. Taking $\alpha\pi$ as the reference line, I have mapped Puppis in Argo Navis, as shown below. In all 17 eye-estimates of distance and angle have been made, but those that follow are the most important:

$\angle\ \alpha\ \pi\ \kappa = 180°$, St. Line
$\pi\ \kappa = 2/3\ \alpha\ \pi$
$\angle\ \alpha\ \pi\ \zeta = 90°$
$\pi\ \zeta = 3/5\ \alpha\ \pi$

$\angle\ \zeta\ \sigma\ \pi = 90°$
$\zeta\ \sigma = \sigma\ \pi$
$\angle\ \alpha\ \tau\ \zeta = 180°$
$\alpha\ \tau = 2/5\ \alpha\ \nu$

Several double stars in Puppis and the cluster about α deserve notice. For these objects, as well as for two or three faint stars, opera-glasses were used.

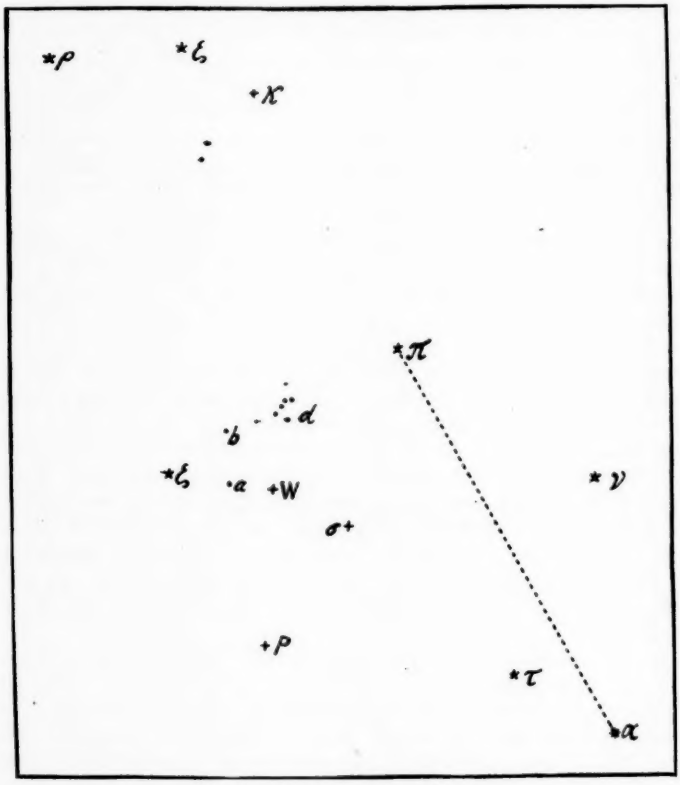


Fig. 1. Puppis in Argo-Navis.

The closing sentence of the above observation suggests an exercise in connection with the map that is interesting to almost every one, that is, noting whether there are in the constellation any stars of remark-

able brightness, of pronounced color, a conspicuous nebula, or star-cluster. The method itself may not appeal to many, the large number of numerical estimates may savor too much of that dread subject, mathematics. However, the method is not essential, no method is. The prime requisite, the one essential, consists in obtaining on paper a true likeness of a small section of the heavens in which there is a close agreement, star for star, between map and sky.

Before turning to our last topic, the summary of exercises for this lesson, it is a pleasure to state that reports of observations, not already mentioned, have been received from three additional states, New York, Missouri, and North Carolina. Later they will receive further attention.

LESSON IV.

1. Give the symbols of the planets, following their order from the sun. Learn the names and symbols of the signs of the zodiac.

2. Explain what is meant by an eclipse of the sun, of the moon, also why the moon is at one phase for the former, and at another for the latter. Find from the almanac what eclipses occur during the year and which ones should be visible from your station.

3. *a.* Observe the total lunar eclipse of May 2, and as far as possible answer the following questions regarding times, contacts, shadow, and general features, depending mainly upon the unaided eye.

When is it certain that the eclipse has begun? When ended? When is it certain that totality has begun? When ended? Hour and minute should be given.

What is the color of the shadow when first seen? Do color and darkness remain the same throughout the eclipse? Is it possible to distinguish lunar objects within the shadow with the unaided eye? With opera-glasses?

Is the moon visible when totally eclipsed? If so, what is its color? When does the Milky Way regain its usual brightness? What planets are visible during totality?

Sketches should be made showing the dark and illuminated portions, when the moon is nearly in the shadow or just coming out, and during totality its place should be fixed in reference to neighboring stars.

b. If it is not practicable to observe the eclipse, identify five additional constellations, including seven or more stars in each.

4. On the date when the April path of the sun is determined, note carefully the point of sunset in reference to objects on the horizon; and, as it begins to grow dark, watch for the first stars that appear in that vicinity, so as to identify the zodiacal constellation that is then only a little east of the sun. This, as is readily seen, is the first step in finding out for ourselves whether the sun appears to move among the stars.

5. Begin a series of five-minute observations of Mars, locating its

position approximately, at some fixed hour, say 9 P. M., by referring it to the horizon or meridian. An ideal series would consist of a number of locations, separated from one another by ten days or two weeks and continued until at the given hour the planet is approaching its setting point.

6. Make a map of the constellation in which Mars is found this month, including ten stars.

7. Place Mars on this map, and give, in the accompanying notes, the estimates on which its position is based.

8. Making your own choice, map a second constellation.

9. Examine both these constellations for objects of special interest, and describe in detail their appearance as seen with the unaided eye and with opera-glasses.

10. Find the field of view and the magnifying power of the glasses used.

May the skies be clear for all who watch the moon as it passes into eclipse next month, and may some remember to write out notes and send reports.

Route 9, Box 77, Lawrence, Kansas.

THE CARDINAL POINTS OF THE TELESCOPIC FIELD.

By J. ERNEST G. YALDEN.

One of the first steps in the identification of variable stars is to learn how to hold the chart correctly; or what is the same thing determine the position of the cardinal points as they will appear in the telescopic field.

The usual method is to determine the direction of a star's motion through the field by observing the points of ingress and egress of that star. This gives the direction of the east-west line in the telescopic field, and the chart is then held so that its east-west line shall be parallel to that line.

While correct in theory it takes a lot of time to do this in practice, especially with slow moving stars, or when a diagonal eyepiece is used in the different positions for convenient observations.

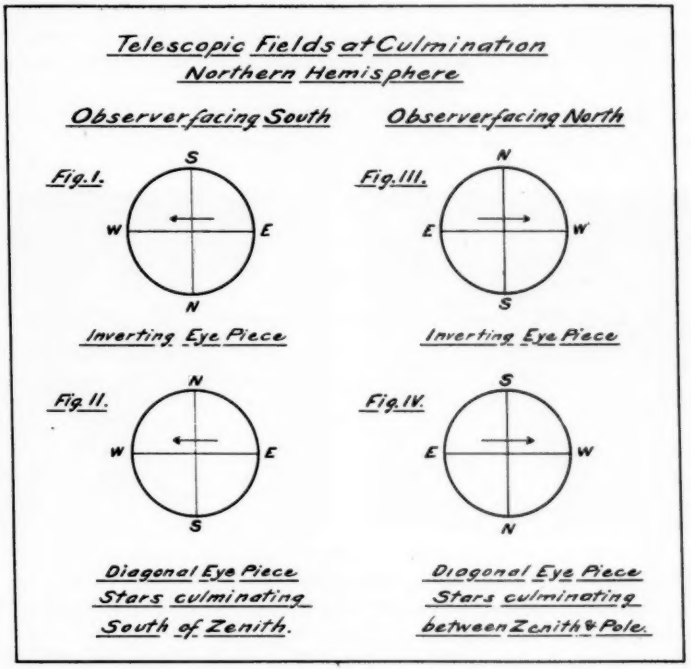
The device about to be described was devised to be attached to any telescope equatorially mounted, and will at once indicate the cardinal points of a telescopic field with either an inverting eyepiece, or a diagonal used in any position.

The problem of orienting the field for the varying positions of the asterisms in different parts of the sky is a comparatively simple one

with the usual inverting eyepiece; but becomes more complicated when the diagonal is used.

Figures I, II, III and IV will show for those bodies culminating south of the zenith and between the zenith and the pole, in the northern hemisphere, the position of the cardinal points in both the inverting and diagonal telescopic fields.

Imagine ourselves at the center of the celestial sphere upon which



hour and declination circles are represented. Pointing the telescope to a star culminating south of the zenith, the hour circle would appear as the line SN in Fig. I, and the declination circle as the line WE, with reference to the observer's horizon.

As the telescope follows a star's motion from culmination to setting, the line WE in Fig. I will change its angle with reference to the observer's horizon, the range being from the position shown to that of an angle to the horizon equal to the co-latitude of the observer.

The movement of the cardinal points with reference to the horizon would be one of rotation, and so if the cardinal points were marked in the field when the telescope is in the plane of the meridian as shown

in Fig. I, then those points would rotate about the optical axis of the telescope as it follows the motion of the star.

Fig. V represents the device as used with an inverting eyepiece. A is a ring with cardinal points indicated attached to the rack and pinion tube, B a set screw so that it may be clamped in the proper position when the telescope is in the plane of the meridian, as shown in Fig. I, or when the declination axis is parallel to the horizon.

One setting is sufficient provided the telescope is used on one side of the pier; if used on the other side of the pier the ring A must be clamped in its proper position when the declination axis is parallel to the horizon. That is, the S point must always be uppermost when the telescope is pointing south.

If the telescope is now pointed in any direction the position of the cardinal points of the telescopic field is at once indicated.

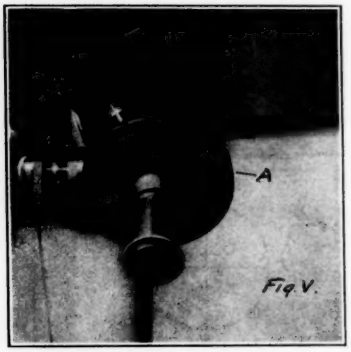


Fig. V.

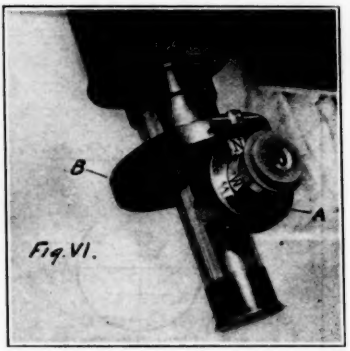


Fig. VI.

Fig. VI represents the device as used with a diagonal eyepiece. A is a ring with cardinal points indicated fitting snugly on the angle piece of the diagonal, but capable of being rotated about its axis. B is the ring as shown in Fig. V, and which remains on the telescope when the adapter tubes are withdrawn.

If when the telescope is in the plane of the meridian and pointing south, the disc B be set as shown in Fig. I and the disc A as in Fig. II, then the position of the cardinal points of the diagonal field for any position of the telescope will at once be indicated.

However in some settings the diagonal will be in an inconvenient position for use, in which case the diagonal is turned so as to be in a more convenient position.

This procedure will alter the appearance of the field, but if after turning the diagonal we turn the disc A so that one of its cardinal points coincides with its opposite point on the fixed disc B, then the true positions of the points are at once shown on the disc A. That is,

N point on the movable ring A must coincide with S point on the fixed ring B, or E with W, etc.

Those mechanically inclined might make the two discs of the same diameter and meshed together with miter gear teeth, in which case disc A would automatically assume the correct position; but the idea is to present a simple device that anyone can easily attach to any telescope.

ASTRONOMY IN DAILY LIFE.

By GILBERT P. CHASE,
Commander U. S. Navy.

In this article I ask the reader to look kindly with me at some practical problems in daily life coming within the province of Astronomy. The first thing I want to tackle is the "daylight-saving" scheme. To make my argument clear I will have to explain the terms used which may not be familiar to the general reader. Time is a word not easily defined in concrete terms. "Time is money", "Time is life", "Time is everything", are all good definitions. An instructor in Navigation at the Naval Academy used to spring this on every bunch of new faces:

"Mr. Soandso, what is time? What is time, Mr. Soandso?"

After Mr. Soandso had emitted a few words or sentences of the kind he would expect to find in an unabridged dictionary, the instructor with the air of a Little Johnny Horner, would announce to the class in triumphant finality:

"Time is an hour-angle, Mr. Soandso; time is an hour-angle."

That is a very good definition. Our ordinary conception of time implies reference to something—usually the clock. Before the clock there was the sun-dial and other means of measuring the time of day. The clock was invented to give a better representation of the apparent daily motion of the sun than could be gotten from the sun-dial or other devices. What the time-piece really conveys to our minds is the position of the sun in reference to our meridian. *The Meridian* is an imaginary plane passing through the poles of the earth and of the heavens, through the spot of the observer on the earth, and the corresponding spot in the heavens or Zenith; and cutting the plane of the Equator at right angles. The trace of this plane on the surface of the earth makes the meridian of longitude. The time for any place with reference to the sun or time of day is measured by the hour-angle or angle between the meridian passing through the sun and the meridian of the observer, called *The Meridian*. When the sun is on *The Meridian*, the hour-angle is zero and the time is noon for the upper

culmination of the sun, and midnight for the crossing of the lower or opposite side of *The Meridian*. Time measured by the sun we see, or the Apparent Sun, is called Apparent Time. With reference to the place we are in it is Local Apparent Time (L. A. T.), and for Greenwich Observatory in England, it is Greenwich Apparent Time (G. A. T.). We observe that the sun is more nearly overhead in summer than in winter, and that the direction of rising and setting varies with the seasons. The early clock makers had a hard time trying to get their clocks to "keep step" with the sun. After a few days they would not come together on *The Meridian* at noon. I believe the Russians still try to make their clocks follow the real or Apparent Sun, and they have to be setting them "all the time" to do it. Foreigners, especially Americans, find this quite a nuisance. Other nations, not being content like Russia, to remain three or four hundred years behind the times, have long been regulating their clocks by a mental creation called the Mean Sun. This gentleman is more regular in his movements, and the clocks have no difficulty in keeping pace with him. Time taken from this fictitious Mean Sun is called Mean Time. For the place of the observer it is Local Mean Time (L.M.T.), and for the Observatory at Greenwich, Greenwich Mean Time (G.M.T). Chronometers used by English-speaking navigators are usually set to Greenwich Mean Time. The difference between Apparent Time and Mean Time at any instant is known as the Equation of Time (Eq.t.); it is shown in the Nautical Almanac for the purpose of converting one kind of time into the other. The Equation of Time is rarely more than sixteen minutes, the average for the year being less than ten minutes. This variation of clock-time from the time indicated by the real sun or Apparent Sun is not enough to upset our schedule of ordinary daily life based on the periods of daylight and darkness.

There is another discrepancy between clock-time and actual sun-time which comes from the system of Standard Time belts or zones to which the clocks are set. If we should cross the ocean from New York to London without changing the time on our watches, we would find our time to have us looking for a lunch counter about the hour the of Englishman's afternoon tea. To avoid having our time fast or slow or else be setting our watches all the time as we travel West or East, we have the arrangement of Standard Time. Going West from Greenwich the clock is set back one hour for every fifteen degrees of longitude, so that when we get to New York we have seventy-fifth meridian time on our watches, which is five hours slow on Greenwich time. At sea it is the custom for the clocks on board to be set once or twice a day when going East or West, according to the speed of the vessel and the daily routine. This practice may bring ships at sea into company with different time on the ship's clock. For Naval vessels in company at sea a time signal is made daily by the Senior Officer to keep the same time on all the vessels. I believe there is a movement starting to

keep the time belts at sea the same as on shore. Having looked into the reasons for the use of the fictitious Mean Sun, and the Standard Time belts, we may accept the resultant discrepancy between sun-time and clock-time as practically unavoidable.

With this understanding I can draw up my argument for the prosecution against the "daylight saving" scheme.

Starting with time, the hour-angle; the hour-angle of the sun is the angle at the pole of the heavens between *The Meridian* and the meridian passing through the sun at any time. To the navigator, time is an hour-angle, time is longitude, time is position. For those who have been to sea, and for those who have worked in the open fields, noon has a familiar, practical, and definite meaning. It is that instant in the day when the sun reaches the highest point in the heavens after the morning climb; it is the culmination of the sun, from which it descends in the afternoon to the Western side of the world. Noon means that the sun is "on *The Meridian*," that the hour-angle of the sun is zero, and the time is 12 hours or 0 hours.

Quarterdeck, fo'c's'l, and "the mast", are not exactly what they were in the Navy thirty of forty years ago. The construction of ships has undergone a radical change, the qualifications of officers and seamen are different, and time-honored customs have suffered corresponding modification. "Pipe to dinner" and "Set the watch" have not the same ring through steel bulkheads, compartments, and superstructure of the present-day fighting ships as these familiar sounds had fore-and-aft along the clear open decks of the old-time frigate and ship-of-the-line. In the "good old days" of the sailing ship, the ship's clocks were set at seven bells, or one half hour before noon to the local apparent time of the ship's estimated position.

This is what took place at noon; here is the high ceremony of the sea. Ten minutes before noon, the Navigator, sextant and watch in hand, accompanied by his assistants, appears on deck. They "shoot" the sun until it "dips", or appears to go below the horizon, as seen in the sextant mirrors. The Navigator, having determined the instant of culmination, salutes, and reports to the Captain on the quarter-deck,

"Twelve o'clock, sir."

The Captain, returning the salute, signifies his approval by announcing,

"Make it so".

The Officer-of-the-Deck, proceeding to "make it so", raises the trumpet to his mouth and gives the order,

"Strike eight bells; set the watch. Pipe to dinner".

This order is followed by the striking of the ship's bell, the shrill piping of the Bos'n and his mates, a tumbling down the hatch ladders, and a period of stillness on the spar-deck, while the mess-deck is the busiest place on the ship. This is the way it was actually done when I crossed the Atlantic on the corvette "Monongahela", on my first

practice cruise at the Naval Academy, twenty-five years ago. The ancient ceremony has lost in impressiveness in the change from sail to steam; but one fact is now as it was then, and ever has been—it is noon, twelve o'clock, eight bells at sea, when the sun is on *The Meridian*. To the seaman, there is a feeling of something actual, practical, about the sun being on *The Meridian* at eight bells or twelve o'clock, akin to the feeling of the dinner being on the table.

During the summer of 1918, while "daylight saving" was in effect, I was in command of the Receiving Ship at New Orleans. When we piped to dinner at twelve of-the-clock, it was one hour before noon. At the one o'clock muster, it was noon, the sun being then on *The Meridian*. When the whistle blew at the end of the regular working hours in the Naval Station, at 4:30, the sun was only three and a half hours from *The Meridian*: it was the very hottest part of the day. With the longest days in June, the sun did not set until 8:30 by the clock; then it went down like a glowing coal, burning hot. I have had the experience of two consecutive summers in New Orleans with the "daylight saving", and in my opinion, it is neither beneficial nor necessary for the latitude of New Orleans. I believe as much may be said of every other place in the world. Let us have our noontime or twelve of-the-clock as near the time of the sun's culmination as we can; let us not purposely set it one hour away from the sun on *The Meridian*. To the sailor, the farmer, the worker in the open, there is something real about noontime, with the sun on *The Meridian*, the shadow falling North-and-South, and the dinner on the table. Let us not deliberately take away from the noon hour its real meaning.

The "daylight saving" may have been a good thing for a war-time measure. Results had to be gotten, and gotten quickly. It was easier to change the time on the clocks than to change the fixed habits and customs of masses of people. The war is over now. Let us not delude ourselves longer by making it appear that we can cause the sun to go out of his way to keep up with the tide of humanity that ebbs and flows in our great cities. Let us stick to the fundamental truth, and adjust our daily life to it.

There is something more to say about time. The Civil Day of ordinary life begins and ends at midnight. The practice of calling the twelve hours before noon "A. M." and the twelve hours after noon "P. M." prevails in many countries. Astronomers begin and end their day at noon. They may have good reasons for doing it that way, but I could never see for myself why they do it. Once their day is started, however, they measure the hours from 1 to 24 without "A. M." or "P. M." In that respect they have an advantage over us ordinary people.. Navigators do not profess to be more than ordinary people, yet they must have something to do with the Astronomers' time to keep up with their business. This little knowledge is a troublesome thing in its acquisition and in its use. It keeps the Navigator going continually

from Astronomical Time to Civil Time and vice versâ. For example, 10 A. M. 15 March in Civil Time is 22 hours, 14 March in Astronomical Time. We, in America, are accustomed to think of G. M. T. as Astronomical Time, because the data in the Nautical Almanac are given for the time of day Astronomically speaking. Our time in New York is five hours slow on Greenwich Time, and in New Orleans, six hours slow on Greenwich. In England people use Greenwich Mean Time in daily life as well as for working problems in Nautical Astronomy. The only way we can make a mistake in the time over there is by not having a clear understanding of whether Astronomical or Civil Time is meant in each instance. I crossed the Atlantic Ocean seven times Eastbound with a contingent of troops and cargo, starting with the first Expeditionary Forces in June, 1917. When we had orders about crossing a meridian or making contact "over there", the hour was specified in G.M.T. The question arose more than once as to whether the time mentioned in orders referred to Greenwich Civil Time or to Greenwich Astronomical Time. There were cases where a misinterpretation would introduce an error of twelve hours into the calculation. I remember one conference of officers of the Convoy and Escort prior to departure, when the Convoy Commander, speaking about the question of time in the orders said,

> "It's no use wasting time on that point. We can work it out until we decide on the right answer before we start, but one thing is certain—when we get on the other side, we will be sure to take it the wrong way; so what's the use?"

In France the hours of the day are counted from 0 to 24, from midnight to midnight. The office-hour signs are marked 14h to 16h, etc. On programs and other announcements it is the same. I have a watch bought in France, that has the hours in black on the outer circle from 1 to 12 for forenoon, and in red on the inner circle 13 to 24 for afternoon. Our "radio day" is based on the same idea. The day of the month, hour, and minute are expressed in a group of figures, of which the meaning is clear to all familiar with the system.

Having our Civil Day starting at midnight and divided into "A. M." and "P. M." time, and the Astronomical Day beginning at noon, and expressed in hours from 1 to 24, can we not shift the point of origin for the Astronomical Day to midnight, and cut out the "A. M." and "P. M." in our Civil Day, making the Astronomical Day, Civil Day, and Radio Day, all one and the same, starting at midnight, and running from 1 to 24 hours? The Nautical Almanacs already published can readily be adjusted to the new system by changing what is now noon of 0^h to noon of 12^h G.M.T. The French and other nations have "arrived" with the Civil Day of 24 hours, without "A. M." or "P. M." Let us have that, and also the Astronomical Day starting at midnight the same as the Civil Day. The time that students and navigators have

to spend on the problems of Civil-Astronomical-Time can be saved, and used to much better advantage.

The practice of writing dates "15 March 1920" instead of March 15, 1920, is coming into vogue in Naval circles, as a result of the War College teaching. It avoids such combinations of figures as December 19, 1919, which occur twelve times every one hundred and one years. Those who have used the "War College Style" will have no other. Let us hope that the converts to this practice will increase like the mustard seed, so that by 20 January 2020, the other method will be decidedly archaic.

One more thing we want—longitude, 0° to 360°, starting Eastward from Greenwich, instead of 0° to 180°, East and West, as we have it now.

All these things we want for those who are living now and not in the past. Simplicity in these things of daily life and constant use will give us that much more time to study the latest models in automobiles and flying-machines.

New Orleans. 17 February 1920.

SOME PROBLEMS IN SIDERIAL ASTRONOMY.*

By HENRY NORRIS RUSSELL.

The main object of astronomy, as of all science, is not the collection of facts, but the development, on the basis of collected facts, of satisfactory theories regarding the nature, mutual relations, and probable history and evolution of the objects of study. Before the existing data appear sufficient to justify the attempt to form such a general theory, two policies of investigation may be followed: (1) to collect masses of information, as accurate and extensive as possible, by well tested routine methods, and leave it to the insight of some fortunate and future investigator to derive from the accumulated facts the information which they contain regarding the general problems of the science; (2) to keep these greater problems continually in mind, and to plan the program of observation in such a way as to secure as soon as practicable data which bear directly upon definite phases of these problems.

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Much valuable and self-sacrificing work has been done by astronomers who adopted the former policy. In the opinion of many investigators, however, the progress of astronomy would be hastened if fuller consideration were given to the second method of attack, especially with a view to the widest possible coöperation between different observers and institutions.

In the hope that the committees of the National Research Council may be of service in furthering such coöperation, and at the request of the Chairman of the Council, the following survey has been attempted of the general problems of sidereal astronomy, and of investigations which at present promise advances toward their solution.

I. The Individual Stars.—Existing methods of investigation have already put at our disposal a great mass of information regarding the physical characteristics of the stars—mass, density, luminosity, color, spectrum, temperature, and so on. The central problem of stellar astronomy may be formulated as follows: From the existing data, and from all further data which may be secured by methods new or old, to deduce a theory of stellar evolution, that is, of the changes in the temperature, density, brightness, spectrum, and other observable characteristics of a star with the progress of time, and of the dependence of these changes upon those factors which are invariant for a given system, such as mass, angular momentum and chemical composition. Such a theory must satisfactorily represent the observed properties of the general run of the stars, and the relative abundance of the different types, and must be capable of extension so as to account for the exceptions to the usual rules.

Among the subsidiary problems whose solution is bound up with that of the main problem are (*a*) that of the evolution of binary systems whether by fission, tidal action, or otherwise; (*b*) that of the causes and mechanism of variable brightness among the stars; (*c*) that of the source of the energy which the stars radiate into space in such enormous amounts.

These problems of stellar astronomy are mainly physical in character, though some phases, such as (*a*), are mainly dynamical.

II. The Galactic System.—The great majority, if not all, of the visible stars appear to belong to an assemblage limited in space, either by regions nearly void of stars, or by absorbing material which conceals whatever may be immersed in it. Within this galactic system we may investigate the distribution of the stars in space, and its variation for stars of different spectral type, absolute magnitude, etc., the motions of the stars (including the Sun), and the phenomena of preferential motion ('star-streaming') in certain directions, and the dependence of these motions upon spectral type, absolute magnitude, etc.; and the association of the stars into sub-groups, or clusters, and the motions of these clusters.

All these studies lead up to a single ultimate problem, which may be

defined as the representation of the present positions and motions of the stars as a stage in the history of a dynamical system (whether in a steady state or not) and the deduction of the presumable history of the system in the past and the future. Among the subsidiary problems connected with this are (*a*) the existence, character, distribution and gravitational influence of possible dark or absorbing matter in space; (*b*) the relation between the age or evolutionary stage of a star and its position and motion within the galactic systems. The latter connects the problems of stellar and galactic evolution in such a way that any notable advance in the solution of one is likely to be of aid in that of the other, while an unfounded assumption regarding either will probably confuse the discussion of both.

III. Clusters and Nebulae.—So little has been known of these objects until very recently that the problems which they present can hardly yet be coördinated into a single statement. Among the most obvious are:

(1) The relations of clusters and nebulae to the galactic system. It now appears probable that the galactic system is very much larger than was supposed a few years ago, and that not only the irregular clusters, and the gaseous nebulae, both planetary and extended, but also the globular clusters, and probably the Magellanic Clouds, lie within its confines. But the relations of the spiral nebulae are still uncertain.

(2) Motions and dynamical relations within clusters, especially globular clusters, and explanation of the law of distribution of stars in such clusters.

(3) Nature of the gaseous nebulae, especially of 'nebulium,' and cause of their luminosity. Internal motions in gaseous nebulae.

(4) Nature of spiral nebulae, and explanation of the rapid motions of their parts.

In all these cases a persistent attempt should be made to account for the observed phenomena by means of the known properties of matter and forces of nature, and the existence of unknown forces should be postulated only if there is apparently no escape from the necessity of doing so.

It may now be profitable to survey rapidly the different fields of astronomical investigation, and consider the bearing of various researches —some now under way, some practicable at present, and others desirable if means for effecting them can be devised—upon these general problems.

1. *Spectra.*—It seems to be increasingly clear that the master-key to these problems, so far as they have yet been formulated, lies in the investigation of the spectra of the stars and other bodies, and the correlation of their other characteristics with the spectra. Fortunately, the spectra are among the few characteristics which can be investigated independently of any knowledge of the distances of the various bodies, —and, indeed, of the distances themselves, except for the limitation arising from the faintness of most of the remoter objects.

(*a*) Two fundamental facts appear upon the study of the lines of stellar spectra. The first is that almost all of the thousands of lines which have been observed are identifiable as those of known elements, and can be reproduced under conditions which can be realized in terrestrial laboratories. The few outstanding exceptions are yielding year by year. The recent identification of the G band in the solar spectrum as due to hydrocarbons,[1] and of the bands of ammonia[2] and water-vapor[3] in the ultra-violet, leaves very few 'unknown' solar lines of any importance. Nor are there any of great account in stellar spectra, except in stars of the fourth type (Class N) and in the Wolf-Rayet and 'early' helium stars.

So many of the lines in the latter have recently been found to be identical with those given in the laboratory by familiar elements (such as hydrogen, oxygen, carbon, and helium), under unusually intense electrical excitation[4] that there is good reason to hope that further researches in this direction may account for those which still remain, and even solve the long-standing riddle of the origin of the characteristic nebular lines (which are associated with the Wolf-Rayet lines in the nuclei of planetary nebulae and in new stars at certain stages). The spectrum of the solar corona, however, still remains an isolated problem.

(*b*) The second great fact is that the vast majority of stellar spectra fall into a single, continuous, linear sequence, which forms the basis of the Harvard system of classification, now generally adopted. Almost all the spectra which did not obviously belong to this sequence have been brought into connection with it by the recent work of Wright,[5] connecting the gaseous nebulae with the Wolf-Rayet stars at the head of the series, and that of Curtiss and Rufus,[6] which shows that the small but definite classes R and N form a sort of side-chain, branching from the main sequence near the other end, at class G (or perhaps K). Miss Cannon's experience[7] in classifying over 200,000 spectra shows that the objects that do not fall into the sequence, thus extended, are almost vanishingly rare.

The general characteristics of this sequence are now well established, and the types which were selected, by a sort of survival of the fittest, in the evolution of the Harvard classification prove to have been surprisingly well distributed along the series. With the aid of the quantitative methods of classification developed by Adams and Kohlschütter,[8] the precise classification of any spectrum of which a good

[1] Newall, Baxandall and Butler, *Monthly Not. Roy. Astron. Soc., London*, **76**, 1916, (640).
[2] Fowler, A., *Proc. Royal So., London*, A, **94**, 1918, (470).
[3] Fowler, A., *Ibid.*, A, **94**, 1918, (472).
[4] Fowler and Brooksbank, *Monthly Not. R. A. S., London*, **77**, 1917, (511-617).
[5] *Astrophy. J., Chicago*, **40**, 1914, (466-572).
[6] Curtiss, R. H., *Popular Astronomy, Northfield, Minn.*, **25**, 1917, (279-285).
[7] Cannon, Miss A. J., *Ibid.*, **24**, 1916, (656).
[8] Adams, W. S., these *Proceedings*, **2**, 1916, (143).

photograph with suitable dispersion is available should be an easy matter, even in the interval between G and K5, where the differences between consecutive types are least prominent. The publication of a detailed descriptive 'key' with good reproductions of photographs of spectra of each successive class would however be a great boon to isolated workers.

Of much greater importance is the devising of some method for photographing the spectra of stars fainter than the tenth magnitude—which are now about at the limit of accessibility. Long exposures with the objective prism are greatly embarrassed by difficulties in guiding, but the problem is doubtless soluble in some way, and ought to be solved.

(*c*) There is now good reason to believe that the differences between the main classes of spectra arise from differences in the effective surface temperatures of the stars, and that differences in their other physical characteristics play only a minor rôle in the spectra, but reveal themselves in differences in detail, formerly described as 'peculiarities' when they were noticed at all. The investigation of these finer differences is today the most promising field in stellar spectroscopy.

What valuable results may be obtained was shown by Hertzsprung's[9] work on Miss Maury's 'c-stars' (with unusually sharp spectral lines) which prove to be of greater real brightness than any other class of stars so far known; and later, and still more remarkably, by Adams' and Kohlschütter's[10] discovery that the absolute magnitudes of stars (of the 'later' spectral classes, at least) can be predicted with surprising accuracy from the relative intensity of a few pairs of lines in their spectra. The data for stars of great luminosity are still scanty, but should be easily obtainable, using the hundreds of spectrograms now available at the great observatories, and determining the mean absolute magnitude of groups of stars, which the spectroscopic method indicates as being of similar brightness, by means of their parallactic motions. When this has been done, our knowledge of the distribution of the naked-eye stars in space will be very greatly advanced.

The careful comparison of the spectra of pairs of stars otherwise similar, but known to differ in other characteristics than absolute magnitude, may yield results of importance. Many recognizable spectral 'peculiarities' too, such as the diffuseness or sharpness of the lines, the presence of bright lines, the abnormal strength or weakness of certain lines, etc., have as yet been very incompletely studied, especially as regards their relation to other characteristics of the stars. For example, it should be possible to distinguish between widening of spectral lines due to a star's rotation (which would affect all lines alike) and widening due to physical conditions in its atmosphere (which are likely to affect some lines more than others).

[9] Hertzsprung, E., *Z. Wiss. Photog., Leipzig*, **3**, 1905, (429-435).
[10] Adams, W. S., these *Proceedings*, **2**, 1916, (147-156).

(*d*) Another promising field is found among the reddest stars. Curtiss makes the very interesting suggestion that the division of the spectral series into the branches G - K - M and G - R - N (or perhaps K - R - N) may be due to differences of chemical composition[11]—since it is known that the surface temperatures of these stars are low enough to permit the formation of chemical compounds. If this is true, the strength of the characteristic bands of titanium oxide or of carbon should depend upon the relative proportions of these elements, and show little correlation with the color index, or the extension of the spectrum in the violet, which depend primarily on the temperatures. There is already considerable evidence that this is actually the case, and it may be remarked that the star Epsilon Geminorum, which is of spectral class G5 has a color index (+ 1.52) almost equal to that of Classes M or R.[12] This star may be in the situation anticipated by Curtiss, in which an exact chemical equilibrium between carbon and titanium oxide suppresses the bands of both.

Photography of the spectra of bright stars in the red, and even the near infra-red, is now practicable, and Merrill[13] has already obtained results of great interest and promise. Investigation of the spectra of the brightest stars with high dispersion is also profitable, as is shown by the work of Adams[14] upon the pressures which probably prevail in the atmospheres of Sirius, Procyon, and Arcturus. Fortunately, the stars brighter than the second magnitude afford examples both of giant and dwarf stars of almost every spectral class.

2. (*a*) Almost equal in importance to the line absorption in stellar spectra is *the distribution of intensity in the continuous background*. The most complete and satisfactory method of studying this would be the direct measurement of the energy carried by different wave-lengths, but this has not yet been proved practicable. A first step has however been taken by Coblentz,[15] who has not only measured the total energy radiation of more than a hundred stars, but in some cases the percentage transmitted by a water cell, thus providing our first knowledge of stellar radiation in the infra-red. With the great reflectors just completed, the determination of spectral energy curves for the brightest stars may be possible.

The distribution of energy in the luminous region of the spectrum is however readily determinable. For the brighter stars, spectro-photometric methods can be employed, as in the visual work of Wilsing and Scheiner,[16] and the photographic investigations of Rosenberg.[17]

[11] See Ref. 6; also Rufus, W. C., *Pub. Astron. Obs. Univ. Michigan, Ann Arbor*, **2**, 1916, (143).
[12] King, E. S., *Ann. Harvard Coll. Obs., Cambridge*, **76**, 1915, (119).
[13] Merrill, P. W., *Popular Astron., Northfield*, **25**, 1917, (661).
[14] Adams, W. S., *Astroph. J., Chicago*, **33**, 1911, (64-71).
[15] Coblentz, W. W., *Lick Obs. Bulletin, Berkeley, Cal.*, **8**, 1915, (104-120).
[16] Wilsing and Scheiner, *Publ. Astrophys. Obs., Potsdam*, **19**, 1909, (5-221).
[17] Rosenberg, H., *Astron. Nach., Kiel*, **193**, 1912, (357-370).

Fainter stars, down to the sixteenth magnitude, at least, can be reached by the determination of *color indices*.

(*b*) In order that these color indices may be capable of full utilization, it is necessary, first, that trustworthy and homogeneous scales of visual, photographic and photovisual magnitudes be established over the whole range of about 47 magnitudes from the Sun to the faintest observable stars. This problem, which is fundamental in all stellar photometry, is already well advanced toward solution. But in the second place, it is necessary that the physical meaning of the units of magnitude should be precisely known; that is, that the 'luminosity curve' which expresses the relative sensitiveness of the photometric receiver for equal energy of different wave-lengths should be exactly determined. And, above all, it is essential that this luminosity curve should be independent of the brightness of the stars under observation. These last two conditions are at present very imperfectly satisfied, if at all. Very little is known about the luminosity curves of the standard plates and apparatus used in the determination of photographic and photovisual magnitudes, and nothing at all about the luminosity curves of the eyes of the 'standard observers' at different observatories,—except that they must be very different under the conditions prevailing at Harvard and at Potsdam.[18] It is certain that the Purkinje effect alters the form of the visual luminosity curve as the brightness of the illumination varies, probable that this affects the visual comparison of the brightness of stars of widely different magnitudes, and uncertain whether, and to how great an extent, similar photographic influences exist.[19]

The direct determination of the luminosity curves for the principal instruments and methods employed in the determination of photographic and photovisual magnitudes would be neither difficult nor laborious. For visual observations it can be derived indirectly, if direct measures prove difficult. To make these investigations at once is urgently desirable, for the present bases of the scales of stellar magnitude are not permanent. The photographic and photovisual scales depend on the properties of present commercial types of rapid plates. which may not be manufactured a few years hence if improvements are devised; and the visual scales are based on the characteristics of the eyes of observers some of whom have already retired from active work.

Such an investigation would also establish a connection between the scales of stellar magnitude and the physical units of measurement of light in the laboratory (which are now defined in terms of a definite luminosity curve), and would enable us to express our stellar photometric data in absolute units.

It is desirable that methods for measuring the brightness of the stars with red and ultra-violet light should be developed, with careful

[18] See *Harvard Annals*, **64**, (126-127).
[19] King, E. S., *Ibid.*, **76**, 1915, (189).

determination of the luminosity curve in each case, and of the color equation which (for normal stars) makes it possible to reduce color indices obtained on any of these systems to a standard scale.

The determination of the colors of faint stars by other methods affords a promising field, as is shown by the success of the method of effective wave-lengths,[20] and of that of exposure ratios,[21] recently developed at Mount Wilson.

Such a determination of exact scales of magnitude and color index is evidently a necessary condition for the full utilization of the great mass of material which is in process of collection concerning the numbers of stars of different magnitudes, their concentration towards the Galaxy, etc.

(*c*) The statistical investigation of the relations between color index and spectral type, and between both and absolute magnitude, have already opened up possibilities of estimating the distances of stars far too remote to be reached in any other way. Such investigations should be extended, with special reference to stars of great and small absolute brightness, and to those having peculiar spectra.

Closely connected with this is the question of possible selective absorption of light in space. Shapley's results,[22] and the theoretical work of L. V. King,[23] appear to negative the existence of any general absorption of this sort. But local selective absorption may occur, and it would be well worth while to study intensively the color indices and spectra of stars in regions where the existence of absorbing matter is suspected, such as Barnard's dark lanes in Scorpius. It is interesting in this connection to note that the three most abnormally yellow stars of Class B (ζ, o and ξ Persei)[24] lie within 5° of one another, in a region full of diffuse nebulosity.[25] A survey of the stars in this region for color index and spectral type would be well worth while.

(*d*) Another interesting problem is presented by the extreme infrequency of very red stars. Color indices up to about + 1.8 on the Harvard scale are fairly common; but greater values are very unusual, and are practically confined to the 'side chain' which includes Class N. In this subsidiary sequence the color indices increase to about + 4, as might be expected as a result of decreasing temperature; but in the main series, ending in Class M, this does not happen. Are all the stars of Class M of about the same temperature, or is an increase of redness in Classes Mb and Mc masked by increasing absorption in the red end of the spectrum? There are certainly very heavy absorption

[20] Hertzsprung, E., *Astrophys. Jour.*, **42**, 1915, (92-110).
[21] Seares, F. H., these *Proceedings*, **2**, 1916, (521).
[22] Shapley, H., these *Proceedings*, **2**, 1916-17, (12-15) and **3**, (267-270).
[23] King, L. V., *Trans. Roy. Soc. Canada, Ottawa*, **9**, 1915, (99-103).
[24] Color index of ζ Persei + 0.16; color index of ξ Persei + 0.03; King, E. S., *Harvard Annals*, **76**, 1915, (118). Color index of o Persei; similar to that of a star of spectrum F, Wilsing and Scheiner, Potsdam Pub., **19**, 1909, (64).
[25] Barnard, E. E., *Astrophys. Jour.*, **41**, 1915, (253-258).

bands in the red in these spectra; and further evidence in favor of this hypothesis is found in Coblentz's measures of Alpha Herculis,[26] which show this star, of Class Mc, radiates far more heat in proportion to its light than do stars of Class Ma, and also in Hertzsprung's[27] observation that the very faint dwarf stars of Class Mb are not nearly as red as their small luminosity, and probable low surface brightness, would lead one to suppose. A careful study of the color indices, and, if possible, of the spectral energy curves, of the stars of Classes Ma, Mb, and Mc is much to be desired. The extraordinarily red stars S Cephei[28] and $+45°53$,[29] which have color indices exceeding five magnitudes, should be included in such a study.

3. One other stellar characteristic which may be investigated without knowledge of distance is *variability of brightness.* If we really understood the causes of stellar variability, we should probably have advanced a long way towards the solution of the whole problem of stellar evolution, if not have solved it completely. But, in spite of the great number of variable stars, the variety of the phenomena which they represent, and the accuracy with which they can now be observed, the humiliating admission must be made that no even tolerably satisfactory theory of the causes of the variation exists, except for the eclipsing variables, and in this case it is based on the proposition that, except for the accident of eclipse, the components are not variable at all!

Successful attack upon the problem of intrinsic stellar variation will probably demand the correlation of all the data that can be brought together from every accessible source. In the case of regular variables, precise light curves are of importance, and many stars still await investigation,—some of them visible to the naked eye, and long known to be variable. The new photometric methods of precision—especially the photoelectric cell—have opened a wide field in the study of bright stars with small variation, in which important results have aready been obtained,—notably by Stebbins[30] and Guthnick,[31]—and more may be anticipated.

(a) Former suspicions of changes in form of the light curves appear to have been unfounded in the case of eclipsing variables; but similar changes are believed with good reason to exist among Cepheid variables.[32] To prove their reality—still more to discover their laws— demands very precise observations, preferably by two or more observers at different places and the same time.

(b) Changes in color, as well as in brightness, appear to be the general, perhaps the invariable, rule among eclipsing variables, and espe-

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[26] Coblentz, W. W., *Lick Obs. Bull.*, **8**, 1915, (121).
[27] Hertzsprung, E., *Astrophys. Jour.*, **42**, 1915, (352-356).
[28] *Harvard Circular, No. 188*, 1915.
[29] Cannon, Miss A. J., *Harvard Annals*, **91**, 1918, (274), (star No. 1546).
[30] Stebbins, J., *Pop. Astron.*, **25**, 1917, (657), and earlier papers.
[31] Guthnick, P., *Vierteljahrsschrift d. Astron. Gesellsch.*, **53**, 1918, (169).
[32] Shapley, H., *Astrophys. Jour.*, **43**, 1916, (180).

cially among Cepheids—the star being always redder at minimum than at maximum. More recent observations show that changes in the spectrum go hand in hand with the others.

In the case of eclipsing variables, these changes arise from a difference in spectral type between the components, and it is found that stars separated by an interval less than their own diameters, and therefore very probably of the same origin and age, may have spectra differing as widely as those of Sirius and Arcturus.[33] Observations of such systems, when the eclipse is total, provide the only direct method at present existing for studying the relations between spectral type, color index, surface brightness, and density, which are of fundamental importance. The determination of the spectral type of the fainter components of such systems, though often very difficult, on account of their extreme faintness, deserves special effort.

(c) The concomitant variations in brightness, color, and spectrum, which Shapley[34] has shown to occur in every Cepheid variable that has been properly investigated, indicate very strongly that the proximate cause of the changes in all three is a periodic variation in the surface temperature of the stars. Shapley's suggestion[35] that these differences in temperature arise from some sort of internal changes, perhaps of the nature of periodic oscillations in the radius, density, temperature, etc., appears to be the best which has been yet made; but there are still grave difficulties in explaining how such pulsations should in all cases produce the very distinctive form of the light curve, with its rapid rise and slow fall, and still greater trouble in accounting for the variations in radial velocity, which show so remarkable a relation, both in amplitude and phase, to those in light. It is in fact still doubtful whether these stars are really binary systems or not. Intensive studies of a number of these variables, including the greatest practicable variety of representative cases, would be well worth while.

(d) Still less is known concerning the very numerous variables of long period, and the roughly periodic and irregular variables. In the observation of their changes in brightness, amateur observers may obtain results of much value, and, under the admirable coöperative schemes organized by the American and British Associations of Variable Star Observers, they are at present furnishing a great mass of valuable information. Very little is known regarding changes in the spectra of long-period variables, except that they often exist,[36] especially as regards the bright hydrogen lines which are usually present at maximum. Observations of the color indices of these variables are also much to be desired. Certain peculiar variables, such as R Coronæ and SS Cygni, are typical of small but definite groups, whose variation,

[33] Cannon, Miss A. J., *Pop. Astron.*, **25**, 1917, (314).
[34] Shapley, H., *Astrophys. Jour.*, **44**, 1916, (273-291).
[35] Shapley, H., *Ibid.*, **40**, 1914, (448-465).
[36] See numerous notes by Mrs. W. P. Fleming, *Harvard Annals*, **56**, (209-212).

though quite distinctive, is entirely unpredictable. The spectra of the stars of the first of these groups are similar to one another, and unlike anything else.[36] Those of the second group are also peculiar, and appear to be variable.[36] Both present problems as alluring as they are difficult. The spectra of other peculiar variables also deserve investigation.

(e) New stars are usually pretty fully observed while they remain bright, but work remains to be done in following at shorter intervals the changes during their later stages. The recent work of Adams and Pease[37] indicates that they settle down into Wolf-Rayet stars; but, according to Miss Cannon,[38] the spectrum of the Nova in Corona, fifty years after its outburst, is now of class K. No one seems yet to have followed up Hertzsprung's interesting suggestion[39] that stars of very small absolute luminosity should be investigated for variability. Abundant material for a photographic study must exist in the Harvard collection.

4. Knowledge of the *distances* of the stars is indispensable in the solution of many problems. The nearer ones, to a distance of thirty parsecs or so, are now accessible to direct measures of *parallax*, and great activity prevails in photographic observation for this purpose, in accordance with a wide and well-considered plan of coöperation.

In my opinion, however, the greatest need in parallax work at present is the investigation and elimination of the systematic errors which are still present in the best work, as is shown by the too frequent appearance of large discordances—sometimes amounting to more than 0″.05—between the results of different observers, although the probable errors derived from the internal agreement of each observer's plates are of the order of ± 0″.01. The intercomparison of the results of various observers for the same stars is hardly a sufficient test for the absence of systematic error, especially as all are using nearly the same method of observation. The only secure control is afforded by observing stars whose parallaxes can be predicted, from other considerations, with greater accuracy than they can be observed. This demands prediction with a probable error not exceeding ± 0″.005. Fortunately, several groups of stars exist for which such prediction is possible. The most prominent of these consists of those stars of spectrum B which are between 60° and 120° from the solar apex. If the parallaxes of these stars are computed on the assumption that their individual proper motions are entirely due to the solar motion, the resulting errors will correspond to a probable error of less than one-third of the parallaxes themselves—that is, to about ± 0″.002. The stars of Kapteyn's Scorpius-Centaurus group[40] would be ideal objects, if they were not too far south.

[37] Adams, W. S. and Pease, F. G., these *Proceedings*, **1**, 1915, (391).
[38] Cannon, Miss A. J., *Harvard Annals*, **76**, 57.
[39] Hertzsprung, E., *Astrophys. Jour.*, **42**, 1915, (118).
[40] Kapteyn, J. C., *Ibid.*, **40**, 1914, (118-126).

For fainter stars, eclipsing and Cepheid variables are available. Of the 90 eclipsing variables whose parallaxes were estimated by Russell and Shapley,[41] 69 are fainter than the eighth magnitude, and the mean parallax of these is 0″.002, while only ten per cent exceed 0″.004. For the Cepheids of similar brightness, the parallaxes estimated by Hertzsprung and Shapley[42] are even smaller.

When once the systematic errors have been tracked to their source and eliminated, an extensive program of observation can be undertaken with security. Much duplication of observations is desirable, for it is obviously better that the parallax of a star should be determined from the mean of three or four short series of as many different observatories than by a series with a single instrument, however long and elaborate. Certain objects for which especially accurate parallaxes are desirable should be observed at as many places as possible. Examples are binary stars, stars differing in absolute magnitude from the bulk of those of the same spectral class, or from the values predicted by the spectroscopic method, stars with exceptionally rapid motions in space, planetary nebulæ, etc. Attempts to determine by direct observation the mean difference in parallax between classes of stars with small parallaxes (for example, those of the third and fourth magnitudes, taken as a whole) should, in my judgment, be deferred until the systematic errors have been thoroughly cleaned out.

5. Knowledge of parallax leads at once to that of *absolute magnitude,* which, in the interest and importance of its systematic relations to other characteristics of the stars, stands second only to spectral type.

(a) The relations between the two afford a very interesting study, which has led Hertzsprung[43] and Russell[44] to the recognition of the two series of "giant" and "dwarf" stars, coincident in class B, but gradually drawing apart among the redder stars until, as Adams' spectroscopic results have recently confirmed,[45] they are completely and widely separated in class M. If Russell's views are correct, the existence of these two series is the key to the problem of stellar evolution. In any case, their existence must be accounted for, and will be of importance in testing any theory. The securing of additional data, especially regarding the absolute magnitudes of individual giant stars, is much to be desired. It is of importance to determine not only the mean absolute magnitude of the giant and dwarf stars of each spectral class (whenever the two are separated) but the dispersion of the individual values about the mean. Only when the latter is known can the results of statistical investigations be cleared from the effects of the egregious observational preference for the brighter and remoter stars.

[41] Russell, H. N., and Shapley, H., *Ibid.*, **40**, 1914, (422-423).
[42] Shapley, H., *Ibid.*, **48**, 1918, (282-287).
[43] Hertzsprung, E., *Zeitschr. f. Wiss. Phot.*, **3**, 1905, (442).
[44] Russell, H. N., *Pop. Astron.*, **22**, 1914, (275-294 and 331-357).
[45] Adams, W. S., these *Proceedings*, **2**, 1916, (157-163).

(b) Kapteyn[46] has obtained fairly good values of the dispersion among the various divisions of Class B, and provisional values for Class A; and Russell[47] has given rough estimates for the dwarf stars, and a still rougher one for the giants of Class M: but further work is greatly needed. Adams' spectroscopic method offers an easy solution of the problem, as soon as his present provisional scale of absolute magnitudes for the giant stars has been revised with the aid of studies of the parallactic and peculiar motions of groups of stars whose spectra indicate that they are similar in real brightness. Strömberg[48] has already shown in this way that Adams' mean absolute magnitude for all the giant stars, taken together, is substantially correct; but there is evidence that the provisional estimates for the very brightest stars(such as the Cepheid variables) make them considerably too faint.[49]

(c) The existing evidence indicates that the majority of the stars of any given spectral class are confined within surprisingly narrow limits of absolute magnitude (provided that the giants and dwarfs can be treated separately). But there are exceptions of great interest. For example, Kapteyn[50] has shown that β Orionis is some eight magnitudes brighter than the average for its class (B8); and the faint companions of Sirius[51] and o^2 Eridani[52] have spectra of class A, although they are at least eight magnitudes fainter than normal stars of this class. Exceptional brightness is probably explicable by unusual size or mass; but the two exceptionally faint stars (which are known to be of normal mass for stars of their brightness) present a real puzzle. Something about the physical conditions in these stars must be very unusual, and they should be studied with the greatest attainable detail. Other such objects may be found among the faint stars of large proper motion.[95]

[*To be Continued.*]

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[46] Kapteyn, J. C., *Astrophys. Jour.*, **47**, 1918, (255-275).
[47] Russell, H. N., *Observatory, London*, **37**, 1914, (167-169).
[48] Strömberg, G., *Astrophys. Jour.*, **47**, 1918, (14).
[49] For example, the mean absolute magnitude given by Adams, (*Mt. Wilson Contribution*, No. 142) for the four Cepheid variables and eight other stars of Miss Maury's classes *c* and *ac*, which appear in his list, is +0.3; and there is abundant evidence from the parallactic motions that the mean absolute magnitude of the stars of this peculiar class is at least as bright as −2, and probably brighter.
[50] Kapteyn, J. C., *Astrophys. Jour.*, **47**, 1918, (263).
[51] Adams, W. S., *Publ. Astron. Soc. of the Pacific*, **27**, 1915, (236).
[52] Adams, W. S., *Ibid.*, **26**, 1914, (198).
[95] As this paper goes to press, van Maanen, (*Pub. Ast. Soc. Pacific*, **31**, 1919, (42)) announces the discovery of a star of type F, and absolute magnitude 14.3 on Kapteyn's scale. If the surface brightness of this object has the value which is ordinarily associated with its color and spectrum, its diameter must be comparable with that of the earth. These faint stars are evidently going to present a problem of great interest and difficulty.

RECENT THEORIES OF STELLAR EVOLUTION.*

By REV. HECTOR MACPHERSON.

We live in a revolutionary age. Within the last few years many old conventions have been challenged and startling ideas propounded both in the world of thought and in the world of action. In the political sphere, crowns and thrones have fallen and social and political ideas of daring import have been freely canvassed; and in the world of thought the same challenging spirit, the same keen desire to know truth at all costs has been manifest. As a result there has been a general revision of established theories and several new conceptions of far-reaching importance have appeared above the horizon. The theory of relativity and its application to gravitation by Einstein and DeSitter has been in all our minds lately. And within the last five or six years, all our ideas concerning stellar evolution have been thrown into the melting-pot.

At the beginning of the century it was believed that the general order of stellar evolution was fairly well-known. Herschel had sketched the evolutionary process in the case of the true nebula; and the invention of the spectroscope and its application to astronomy enabled the earlier astrophysicists to trace the process through the different orders of blazing suns. As early as 1865 Zöllner threw out the idea that yellow and red stars were simply white suns in process of cooling. At about the same time Secchi made at Rome his epoch-making spectroscopic survey of the brighter stars, as a result of which he divided them into four broad general types according to their spectra—white stars, yellow stars, and two classes of red stars. At first this classification was looked upon as more or less empirical and arbitrary, but latterly he came to the view that "it represented real physical conditions varied by the temperatures prevailing on the different stars, though", as Scheiner remarked, Secchi's "ideas as to the connection do not appear to have been very clear."

In 1874 the stars were again classified by Vogel, who sub-divided Secchi's types, while retaining the framework of the Italian astronomer's scheme. "A rational classification of the stars according to their spectra" Vogel pointed out "is probably only to be obtained by proceeding from the standpoint that the phase of development of the particular body is in general mirrored in its spectrum". In 1895 Vogel revised his classification, in order to make room for the class of helium stars which

* Paper read before the British Astronomical Association (West of Scotland Branch) in Glasgow, December 19, 1919.

he separated from the first type altogether. These helium stars he regarded as the youngest and hottest orbs, the evolutionary order progressing through them from the gaseous nebulæ to Sirian stars and then through solar to red stars, which he believed to be "effete suns hastening rapidly down the road to final extinction". In the main Vogel's tentative scheme was adopted by Huggins, and formed the theoretical basis of the elaborate Draper classification carried through photographically under the direction of E. C. Pickering at Harvard. The classification is based upon the observed spectral lines. At the present time it is in general use. In this system the different types are designated by letters of the alphabet, O B A F G K M N—the "mystic order" as Eddington has called it. This order has been generally believed by Fowler, Campbell and other eminent spectroscopists to be the order of stellar development.

Voices had indeed been raised from the beginning in opposition to the general postulate of the Vogel-Draper scheme. Johnstone Stoney had in 1867 expressed the view that red stars were at an early stage of evolution, and Ritter of Aix-la-Chapelle divided red stars into two groups, those increasing in temperature and those decreasing. This view was taken over by Lockyer, who placed stars of Secchi's third type on the ascending scale and those of the fourth on the descending. Probably Lockyer's views would have met with more general acceptance but for their association with his meteoritic hypothesis of cosmogony, in which truth and error seem to have been strangely intermixed. Accordingly, the overwhelming majority of astronomers accepted the order of evolution outlined by Vogel. Strong support, too, seemed to be lent to it by the discovery made independently by Kapteyn and Campbell in 1910 that the radial velocities of stars of the later types were greater than those of the earlier types. These two astronomers demonstrated that the average linear velocity increases from one type to another through the Harvard sub-divisions B A F G K M. On this discovery Eddington remarked in 1911: "This relation of spectral type and velocity is one of the most startling of the results of modern astronomy. For the last forty years, astrophysicists have been studying the spectra and forming their systems by which they arrange the stars in order of evolution. However plausible may be their arguments, one would have said that their hypotheses must be forever outside the possibility of confirmation. Yet if this result is right we have a totally different criterion by which the stars are arranged in the same order."

It was just at this time, however, that evidence began to be collected which cast doubt upon the generally-accepted order of evolution. In a course of lectures at Johannesburg in 1912, Mr. R. T. A. Innes, the brilliant Scotsman who directs the Union Observatory there, expressed the view, based upon physical and chemical grounds, that the true evolutionary sequence is the reverse of the Harvard order, adding that "the fact that we have seen a star change into a nebula outweighs every

contrary speculation that stars originate from nebulæ". As early as 1905 Prof. Hertzsprung of Potsdam had pointed out the existence of two well-defined classes of stars which he named "giants" and "dwarfs"; five years later the same astronomer remarked that there is a certain limit of brightness for each spectral class, below which stars of this class are very rare, if they occur at all. At the same time Dr. H. N. Russell of Princeton commenced the series of investigations which he described fully in lectures before the Royal Astronomical Society and the American Association for the Advancement of Science in 1913. Russell, from statistical results and parallax investigations, recognized Hertzsprung's two classes of giants and dwarfs among the red stars. "There are", he said in December 1913, "two great classes of stars—the one of great brightness averaging perhaps a hundred times as bright as the sun, and varying little in brightness from one class of spectrum to another; the other of smaller brightness, which falls off very rapidly with increasing redness....The two groups, on account of the considerable internal differences in each, are only distinctly separated among the stars of class K or redder. In class F they are partially and in class A thoroughly intermingled while the stars of class B may be regarded equally well as belonging to either series". Doubt was cast in Russell's mind on the generally accepted order of evolution by Dr. Harlow Shapley's work on eclipsing binaries, which indicated a greater density for stars of Secchi's first type than for those of the second. "The order of increasing density", said Russell, "is the order of advancing evolution.....The redder stars then represent successive changes in the heating up of a body and must be more primitive the redder they are; the dwarf stars represent successive stages in its later cooling, and the redder of these are the furthest advanced. We have no longer two separate series to deal with, but a single one, beginning and ending with class M, and with class B in the middle—all the intervening classes being represented in inverse order in each half of the sequence".

Russell's theory showed that the Lane-Ritter law applies to the giant stars on the up-grade; as they grow hotter, they contract. Two well-known facts fit into the theory. (1) The relative scarcity of giant stars of class B (Vogel's type O) is accounted for by the fact that only stars of very large mass are able to attain the unusually high temperature of B-type stars. "Only these stars would pass through the whole series of the spectral classes from M to B and back again in the course of their evolution. Less massive bodies would not reach a higher temperature than that corresponding to a spectrum of class A, those still less massive would not get above class F and so on." (2) "It is now easy to understand why there is no evidence of the existence of luminous stars of mass less than one-tenth that of the sun. Smaller bodies presumably do not rise, even at maximum, to a temperature high enough to enable them to shine perceptibly from the stellar standpoint

and hence we do not see them. The fact that Jupiter and Saturn are dark, though of a density comparable to that of many of the dwarf stars, confirms this view".

There is much to be said for and against Russell's hypothesis. It is a fascinating theory, unrolling before us the whole cosmic process; but it must be admitted that it raises as many problems as it solves—that is, if we regard it as of universal application. Several of the most eminent astrophysicists, such as Fowler, Cortie and Campbell, are hostile; though it is fair to say that Sir F. W. Dyson has accepted it from the beginning and that Prof. Eddington, whose chief characteristic is a fine scientific temper and almost complete freedom from prejudice, has in great measure accepted it and has by his theoretical researches on radiation added to its probability. The theory is confirmed by Hertzsprung's detection of slight differences in the spectra of stars of the various types—a sharpness of lines indicated in Harvard classification by the letter *c*. Striking confirmation too has come from the work of Dr. W. S. Adams at Mount Wilson. In course of his determinations of stellar parallax by the new spectroscopic method, Adams found that "two groups of M stars are indicated clearly by an examination of the intensities of the hydrogen lines: in the first the hydrogen lines are very strong; in the second they are very faint.....Connecting links over a range of seven magnitudes are entirely lacking".

From the day of its promulgation, the difficulties of the theory have been obvious. Eddington in 1915 admitted that "it plays havoc with a great deal that has hitherto seemed orderly and intelligible" and specified "the progression of average speed as we pass from B to M". This objection has not the force it had even four years ago. The work of Eddington himself, and of Kapteyn, Adams and others indicates that the progression of velocity with spectral type is simply a particular manifestation of a wider generalization, namely, the increase of speed with diminishing absolute magnitude—and probably therefore with diminishing mass. Russell's words in 1914 have been undoubtedly justified by later results—"A correlation between mass and velocity ....seems more probable than one between temperature and velocity or velocity and age".

More serious for Russell's theory—assuming the development of stars from visible nebulæ—is the fact that in the decisive words of Prof. Campbell "nebulæ and red stars do not coexist.....If you find a red or yellow star of normal type, do not look for a nebula in apparent contact with it". There are no intermediate types of spectrum between nebulæ and giant stars of class M. On the other hand the B-type stars are often associated with nebulæ—for instance, in Orion—and possess aproaches with Wolf-Rayet stars, which the brilliant researches of Prof. J. W. Nicholson, of London, have shown to be very closely connected with nebulæ. "The continuity", says Nicholson, "between the Wolf-Rayet stars and nebulæ is as certain spectroscopically as in

any other region of the stellar classification. The nature of the relation between the spectra seems to indicate that, in the order of evolution, the Wolf-Rayet stars must have come after the nebulæ". Again Dr. Wright, of the Lick Observatory, has shown that "the nuclei of planetary nebulæ not only are closely related to Wolf-Rayet stars but in many cases they are such stars". Messrs. Adams and Pease have found that four recent temporary stars, after passing through a nebular stage have become Wolf-Rayet stars. These facts harmonize better with the older view than with Russell's hypothesis.

They receive a different explanation in the latest theory of stellar evolution, that of Prof. C. D. Perrine outlined in the *Astrophysical Journal* for June 1918. His article "On the Cause underlying the Spectral Differences of the Stars" is worthy of careful and detailed study. and I do not think it has received the attention it deserves. Perrine has collected a large mass of detail concerning the spectral differences in the components of double stars and the spectral changes in temporary stars. He finds that in the case of binary stars "the relative spectral types of the components depend upon their distances from the sun, those pairs in which the fainter component is of earlier type being distant, whereas those in which the fainter component is of later type are much nearer". Turning his attention to new stars, Perrine states that in the history of Nova Persei (1901), whose spectrum was observed before the appearance of bright lines, "we have a clue of inestimable value as to the course pursued by stellar bodies under conditions operating to produce the different types of spectra". Adopting the theory of the cause of novæ associated with the name of Seeliger, Perrine concludes that "the stage of class B in stellar spectra results from the same general cause as the similar stage in Nova Persei and that the principal difference in the two cases is one of intensity affecting the element of time". The B stars in fact are congregated in the galactic regions because there "the conditions are favourable to the production or maintenance of that spectral stage in a manner analogous to the outbursts of the novæ". Three general assumptions underlie the theory: (1) that the spectral class of the stars is determined in general by location in the system, being a function of galactic latitude and distance; (2) that the more distant regions in the direction of the Galaxy contain a larger quantity of finely divided solid matter than the near regions (a somewhat doubtful assumption); and (3) that the cause underlying the spectral changes among the stars is essentially the same as that producing the phenomena of the novæ. In other words, the galactic regions are filled with cosmical matter which is swept up by the stars—"the energy from the matter swept up being in excess of the energy lost by radiation. The direction of spectral change under such conditions is *toward the nebulae*". This is the startling point of Perrine's theory; the idea, however, is not new, having occurred to Innes, as already mentioned, some years before, but Perrine works it out log-

ically. Perrine's theory finds room—which Russell's does not—for the association of B-type stars with nebulæ and Wolf-Rayet stars, but the connection is the reverse of the ordinarily accepted one between stars and nebulæ. Planetary nebulæ are regarded as the product of Wolf-Rayet stars, which in turn are evolved from B-type stars. The spectral type reached, in short, depends upon "the masses of matter" swept up and the violence of the encounter. The Wolf-Rayet stars result from moderate encounters, the planetary nebulæ from more serious ones, and the large irregular nebulæ from the most violent outbursts of all. "If the initial outburst is great enough, the gaseous nebulosity will be driven off, both by the force of the outburst and by light-pressure, at a speed which will overcome the attraction of the central mass and carry to great distances". Thus on Perrine's theory, nebulæ are the products of the dissolution, rather than the progenitors, of stars. In the extra-galactic region, however, where there is little or no cosmical matter, "radiation will over-power the energy received from distant sources and the direction of change will be toward the late types". It is interesting to notice that Perrine finds room for both orders of development—the Harvard sequence in extra-galactic regions, and Russell's order in the galactic zone; but in his theory, neither of these is of universal application.

It is of some interest that since Perrine published his article, Mr. F. J. M. Stratton, of Cambridge, has announced the result of his detailed study of the spectrum of Nova Geminorum, of 1912,—that that star passed through the A-stage before passing into the B-stage, following the order A, B, O, planetary nebula. Father Cortie has recently found that Nova Aquilæ (1918) passed through a similar cycle of spectral change. The theory of Perrine bristles with difficulties and in many ways seems untenable. Its salient point is that Perrine abandons the effort to fit all the stars into one order of evolution and definitely declares for two sequences, dependent on location in space.

The problem of stellar evolution, then, is by no means so simple as it was ten years ago. We now have three types of theory in the field:

(1) The older theory—originally due to Vogel—which looks upon the Harvard sequence, O B A F G K M, as a true evolutionary succession and regards the line of development as from nebulæ—sometimes through Wolf-Rayet stars—to class B and so on through the sequence. For this theory there is still much to be said—though Rusell has shown that it cannot be of universal application.

(2) The theory of Russell, based on the incontrovertible evidence collected by that astronomer himself and Hertzsprung, and confirmed by others, of a real differentiation of stars into giants and dwarfs. This theory is in close accord with Lane's law of contraction and is confirmed by numerous important pieces of evidence. Nevertheless, it does not explain the position of B-type stars and Wolf-Rayet in relation to nebulæ.

(3) Perrine's theory, which postulates for two different evolutionary tendencies, co-existing at one and the same time in the universe and due to location in the stellar system.

Is it not possible that these three antithetical theories may be combined in a higher synthesis?—that in short there are alternative paths of evolution? May it not be, for instance that the stars which develop from the huge slow-moving irregular nebulæ are of a different order from these which spring from the swift planetaries? Planetary nebulæ are differentiated from the irregular not only by their high velocities but also by the known fact that they are on many occasions the products of the outbursts known as temporary stars: planetaries indeed have been designated as "the wrecks of ancient novæ".

There are three classes of known gaseous nebulæ and I would venture to ask whether it may not be that these represent the beginnings of three different paths of stellar evolution. These nebulæ are:

(1) Irregular gaseous nebulæ, such as that in Orion, associated with helium stars.

(2) Planetary nebulæ, of much smaller dimensions, and comparatively rare, associated with Wolf-Rayet and temporary stars.

(3) The great masses of dark nebulosity which Prof. Barnard, Prof. Max Wolf and others have shown to exist.

Is is not possible that—

(1) From gaseous nebulæ of high temperature—the temperature of the Orion nebula has been estimated at 15,000° C.—the helium stars are born and the order of evolution is the Harvard sequence B A F G K M. These nebulæ may be the products of celestial catastrophes on a great scale. Undoubtedly the results reached by Nicholson demand a development from nebulous matter to stars.

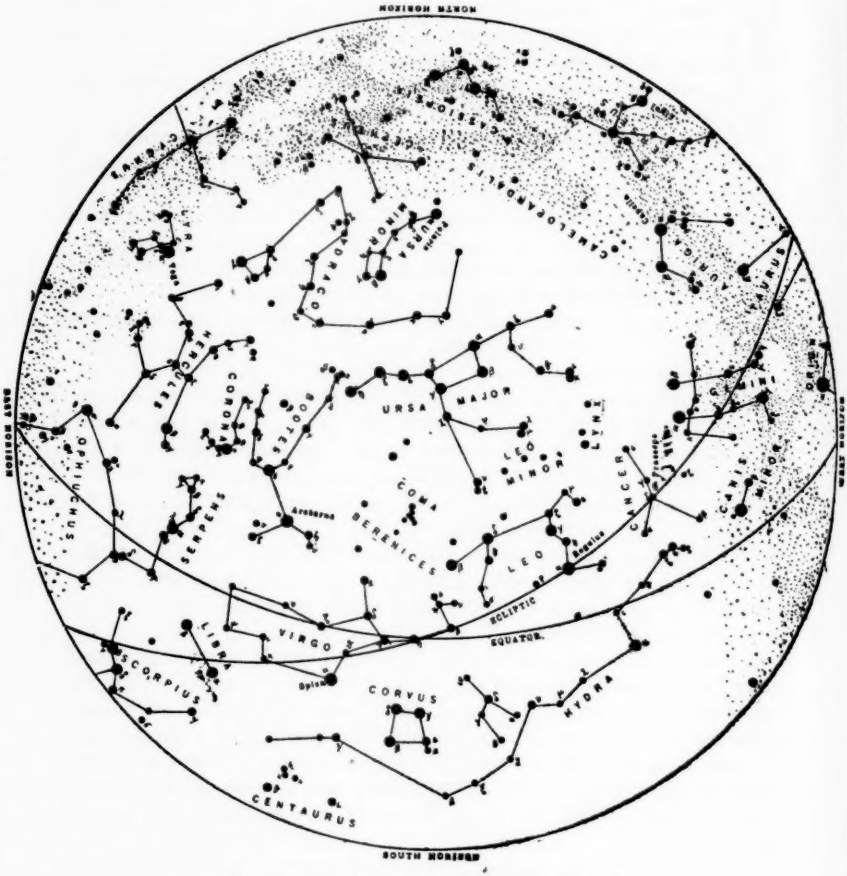
(2) From planetary nebulæ, themselves the result of the passage of effete suns through dark nebulous matter, swiftly-moving dwarf stars may develop, passing through the Wolf-Rayet stage and the Harvard sequence to obscurity.

(3) From the dark invisible nebulæ spring the diffuse red giants of Russell's hypothesis, glimmering out of the night of chaos. While the visible gaseous nebulæ are the result of cosmic catastrophes, these cool giant stars develop out of the dark nebulous matter, itself the product of atomic and interatomic forces. In a sense, this would be the normal sequence of stellar evolution. Both giants and dwarfs would develop in this sequence, while in (1) there would only be giants and in (2) only dwarfs.

I lay no great stress on these ideas, but careful study of recent research and theory in stellar evolution has led me to think that none of the present hypotheses are of universal application, or can explain all the phenomena of stars and nebulæ; and that in the present state of our knowledge the evidence points to the co-existence of several different and alternative paths of development from primeval chaos.

PLANET NOTES FOR MAY 1920.

The *sun* will move northward from 15 degrees north to nearly 22 degrees north during this month. At the end of the month it will be approaching its



THE CONSTELLATIONS AT 9:00 P. M., MAY 1

farthest northern position for the year, and the days in the northern hemisphere will be near their longest. It will move eastward from Aries into Taurus, passing between the Pleiades and Aldebaran. At the end of the month it will be about 5 degrees northeast of Aldebaran.

The phases of the *moon* for the month are as follows:

Full Moon	May 2	at 8:00	P. M.	C.S.T.
Last Quarter	10	" 12:00	P. M.	"
New Moon	17	" 12:00	P. M.	"
First Quarter	24	" 3:00	P. M.	"

The moon will be farthest from the earth on May 6, and nearest the earth on May 18.

Mercury will not be visible during this month. It will move eastward toward the sun until it reaches superior conjunction. On May 25 it will pass the sun and move eastward ahead of the sun, but will not be far enough out to become visible before the end of the month.

Venus will continue its motion eastward, following the sun and gaining slowly on it. It will rise only about one hour earlier than the sun, and will, therefore, not be in favorable position for observation during this month.

Mars will be in very good position for observation. It will cross the meridian on an average about 10 o'clock during the month of May. At the end of the month, it will be directly north of, and less than 2 degrees distant from the bright star Spica. It will, however, be distinguishable from this star because of its ruddy color.

Jupiter will be a short distance west of the meridian at sunset during this month. It will be recognized as the brightest object in that part of the sky. It will be in the constellation Cancer about 15 degrees west of Regulus.

Saturn will be in quadrature, 90 degrees east of the sun, on May 26. It will, therefore, be a very interesting object during this month. The earth happens to be nearly in the plane of the ring at this season, so that this feature of the planet is not so striking. However, the form of the ring can be seen even with small instruments.

Uranus will be in quadrature, 90 degrees west of the sun, on May 26. It will, therefore, be observable during the early morning hours. It will be in the constellation Aquarius.

Neptune will be west of the meridian at sunset, but will be well situated for observation during this month. It will be in the constellation Cancer, a short distance west of Jupiter.

Occultations Visible in the United States, May, 1920

[NOTE:—Geographical positions are indicated by giving for each point, first the latitude, then the longitude, the two being separated by a hyphen. A line drawn on a map through the two or three points thus indicated will mark approximately the limit of the region of visibility for the United States.

The time given is the approximate Greenwich time of the middle of the occultation as seen from the United States.]

May 1, 19^h. 621 B. Virginis, Mag. 6.4. North of 50°-118°, 43°-105°, 38°-85°, 40°-72°.

May 3, 15^h. 41 Libræ, Mag. 5.3. East of 50°-111°, 45°-112°, 40°-111°, and northeast of 40°-111°, 32°-91°, 25°-76°.

May 3, 17^h. κ Libræ, Mag. 5.0. Northeast of 50°-97°, 44°-86°, 39°-73°.

May 4, 22h. 123 B. Scorpii, Mag. 6.5. South of 30°-110°, 36°-86°, 42°-70°. (East of long. 80°, occurs after sunrise.)

May 5, 15h. ξ Ophiuchi, Mag. 4.4. Northeast of 47°-88°, 44°-80°, 40°-72°.

May 6, 17h. 16 Sagittarii, Mag. 5.9. East of 50°-108°, 42°-109°, 35°-108°, and northeast of 35°-108°, 30°-94°, 25°-80°.

May 7, 16h. 173 B. Sagittarii, Mag. 6.4. East of 48°-84°, 41°-82°, and northeast of 41°-82°, 38°-72°.

May 7, 19h. 187 B. Sagittarii, Mag. 6.4. East of 50°-115°, 40°-118°, 30°-117°.

May 20, 16h. 74 B. Geminorum, Mag. 6.2. South of 50°-123°, 45°-112°, 39°-98°, and west of 39°-98°, 33°-100°, 26°-103°.

May 25, 19h. 388 B. Leonis, Mag. 6.3. South of 36°-123°, 34°-104°, and west of 34°-104°, 25°-104°.

May 27, 13h. ψ Virginis, Mag. 5.0. Northeast of 34°-100°, 30°-93°, 25°-84°, and east of long. 100°. (Farther west, occurs before sunset.)

May 27, 22h. 49 Virginis, Mag. 5.2. West of 50°-113°, 40°-114, 30°-116°.

May 30, 13h. 28 Libræ, Mag. 6.2. Southeast of 28°-93°, 36°-85°, and southwest of 36°-85°, 32°-77°. (Farther west, occurs before sunset.)

May 30, 23h. 41 Libræ, Mag. 5.3. West of 50°-118°, 40°-115°, 30°-115°.

May 31, 18h. 58 G. Scorpii, Mag. 6.2. Throughout the U. S. except north of 50°-104°, 47°-94°, 46°-78°.

May 31, 22h. ψ Ophiuchi, Mag. 4.6. Florida, south of lat 28°, only.

ARTHUR SNOW,
Ass't, Nautical Almanac Office, U. S. Naval Observatory.

Phenomena of Jupiter's Satellites

Visible at Washington

[From the *American Ephemeris.*]

CENTRAL STANDARD TIME.

1920	d	h	m				d	h	m		
May	2	7	20	II	Tr. I.	May	13	8	44	IV	Oc. R.
		9	26	I	Tr. I.		17	10	31	I	Oc. D.
		9	55	II	Sh. I.		18	6	48	III	Tr. I.
		10	12	II	Tr. E.			7	21	II	Oc. D.
		10	41	I	Sh. I.			7	47	I	Tr. I.
		11	42	I	Tr. E.			8	59	I	Sh. I.
	3	6	37	I	Oc. D			10	03	I	Tr. E.
		10	13	I	Ec. R.			10	25	III	Tr. E.
	4	7	21	III	Sh. E.		19	8	33	I	Ec. R.
		7	26	I	Sh. E.		20	7	23	II	Sh. E.
		7	28	II	Ec. R.		25	9	44	I	Tr. I.
	5	10	54	IV	Sh. E.			10	00	II	Oc. D.
	9	9	59	II	Tr. I.		26	6	58	I	Oc. D.
		11	22	I	Tr. I.		27	7	07	II	Sh. I.
	10	8	33	I	Oc. D.			7	37	II	Tr. E.
	11	7	05	I	Sh. I.			7	39	I	Sh. E.
		7	45	III	Sh. I.			10	00	II	Sh. E.
		8	07	I	Tr. E.		29	9	15	III	Ec. R.
		9	21	I	Sh. E.		30	9	58	IV	Ec. D.
		10	03	II	Ec. R.						

NOTE.—I, denotes ingress; E., egress; D., disappearance; R., reappearance; Ec., eclipse; Oc., occultation; Tr., transit of the satellite; Sh., transit of the shadow.

Satellites of Jupiter, 1920.

[From the *American Ephemeris.*]

GREENWICH MEAN TIME.

MAY

Phases of the Eclipses of the Satellites for an Inverting Telescope.

I. r

III. d r

II. r

IV. d r

Configurations at 14h 45m for an Inverting Telescope.

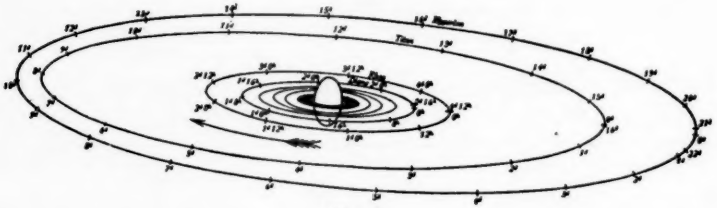
Day	West	East
1	·1 ○ ·2 ·3 4·	
2	○2· 1○· 3· 4·	
3	·2 ○ 3· 4·	·1●
4	3·1· ○ ·2 4·	
5	3· 4· ○ ·12·	
6	4·3· ·2·1· ○	
7	4· ·2 ·3 ○ 1·	
8	4· ·1 ○ ·2·3	
9	·4 ○2·1· 3·	
10	·4 2· ○ 3·	·1●
11	·4 3·1· ○	·2●
12	3· ·4 ○ ·1 2·	
13	·3 2·1: ○·4	
14	·2 ·3 ○ ·1 ·4	
15	·1 ○ ·3·2 ·4	
16	○ 2·1· 3· ·4	
17	2· ·1○ 3· ·4	
18	○3· ○1· ○ 4·	·2●
19	3· ○ ·1 2· 4·	
20	·3 2·1: ○ 4·	
21	·2·3 ○ 4· ·1	
22	4··1 ○ ·3·2	
23	4· ○ 2·1: 3·	
24	4· 2· ·1 ○ 3·	
25	4· $\frac{1}{3}$○$\frac{2}{2}$	
26	·4 3· ○ ·2	·1●
27	·4 ·3 1·2·○	
28	·4 ·3·2 ○ ·1	
29	$\frac{1}{4}$· ○ ·2	·3●
30	○ 1·2· ·3 ·4	
31	2· ·1 ○ ·3·4	

Saturn's Satellites

[From the *American Ephemeris.*]

CENTRAL STANDARD TIME.

South



North

Apparent orbits of the seven inner Satellites of Saturn, at date of opposition, February 27, 1920, as seen in an inverting telescope, and elongated in the ratio of two to one in the direction of their minor axes.

E., Eastern Elongation. I., Inferior Conjunction (south of planet).
W., Western Elongation. S., Superior Conjunction (north of planet).

I. Mimas. Period $0^d\ 22^h.6$.

1920	d	h		d	h		d	h		d	h	
May	1	8.6	E	May 8	10.3	W	May 15	11.9	E	May 23	12.2	W
	2	7.2	E	9	8.9	W	16	10.5	E	24	10.8	W
	5	14.4	W	10	7.5	W	17	9.2	E	25	9.4	W
	6	13.0	W	13	14.7	E	18	7.8	E	26	14.1	W
	7	11.6	W	14	13.3	E	22	13.6	W	30	13.9	E
										31	12.5	E

II. Enceladus. Period $1^d\ 8^h.9$.

May	1	14.6	E	May 9	19.9	E	May 18	1.2	E	May 26	6.6	E
	2	23.5	E	11	4.8	E	19	10.1	E	27	15.5	E
	4	8.4	E	12	13.7	E	20	19.0	E	29	0.4	E
	5	17.2	E	13	22.6	E	22	3.9	E	30	9.3	E
	7	2.1	E	15	7.5	E	23	12.8	E			
	8	11.0	E	16	16.4	E	24	21.7	E			

III. Tethys. Period $1^d\ 21^h.3$.

May	0	20.6	E	May 8	9.8	E	May 15	23.1	E	May 23	12.4	E
	2	17.9	E	10	7.2	E	17	20.4	E	25	9.7	E
	4	15.2	E	12	4.5	E	19	17.7	E	27	7.0	E
	6	12.5	E	14	1.8	E	21	15.0	E	29	4.3	E
										31	1.6	E

IV. Dione. Period $2^d\ 17^h.7$.

May	3	5.1	E	May 11	10.2	E	May 19	15.3	E	May 27	20.4	E
	5	22.8	E	14	3.8	E	22	9.0	E	30	14.1	E
	8	16.4	E	16	21.6	E	25	2.6	E			

V. Rhea. Period $4^d\ 12^h.5$.

May	3	9.7	E	May 12	10.5	E	May 21	11.4	E	May 30	12.4	E
	7	22.1	E	16	23.0	E	25	23.9	E			

VI. Titan. Period $15^d\ 23^h.3$.

May	4	9.3	E	May 12	3.7	W	May 20	8.2	E	May 28	2.8	W

VII. Hyperion. Period $21^d\ 7^h.6$.

May	5	7.2	E	May 15	6.2	W	May 26	12.7	E			

VIII. Iapetus. Period 79d 22h.1.

May 11 17.7 I May 30 17.2 W

IX. Phoebe. Period 523d 15h.6.

	α Ph.—α Sat.	δ Ph.—δ Sat.		α Ph.—α Sat.	δ Ph.—δ Sat.
	m s	′ ″		m s	′ ″
May 2	−0 07.9	+3 08	May 16	−0 25.5	+4 54
4	0 10.5	3 23	18	0 28.0	5 08
6	0 13.0	3 39	20	0 30.4	5 23
8	0 15.5	3 54	22	0 32.9	5 37
10	0 18.0	4 09	24	0 35.3	5 51
12	0 20.5	4 24	26	0 37.7	6 05
14	−0 23.0	+4 39	28	0 40.1	6 19
			30	−0 44.8	+6 47

Saturn.—Harvard College Bulletin No. 714 announces that Professor W. H. Pickering, Mandeville, Jamaica, states in a letter that on the evening of February 22, in examining Saturn, he noticed a narrow but sharply defined dark belt in latitude 60° south.

VARIABLE STARS.

Maxima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5h; Central standard time 6h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1920. May
	h m	° ′		d h	d h d h d h d h
SX Cassiop.	0 05.5	+54 20	8.6— 9.2	36 13.7	1 12
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 1.7	8 14; 16 17; 24 21
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	2 16; 10 10; 18 4; 25 22
RW Cassiop.	130.7	+57 15	8.9—11.0	14 19.2	5 17 19 12
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	4 10; 12 9; 20 7; 28 6
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	7 4; 14 23; 22 18; 30 13
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	1 17; 9 0; 23 14; 30 21
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0	4 20
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	8 1; 16 15; 25 5
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	4 8; 15 12; 26 15
RX Aurigae	4 54.5	+39 49	7.2— 8.1	11 15.0	9 12 21 3
SX Aurigae	5 04.6	+42 02	8.0— 8.7	1 12.8	3 7; 10 23; 18 15; 26 6
SY Aurigae	05.5	+42 41	8.4— 9.5	10 03.3	10 16; 20 20; 30 23
Y Aurigae	21.5	+42 21	8.6— 9.6	3 20.6	6 18; 14 11; 22 4; 29 21
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	4 8; 9 20; 20 22; 26 11
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	6 8; 13 22; 21 12; 29 1
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3	19 10
RT Aurigae	23.0	+30 33	5.1— 6.0	3 17.5	7 9; 14 20; 22 7; 29 18
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	5 21; 13 3; 20 8; 27 12
W Gemin.	29.2	+15 24	6.7— 7.5	7 22.0	3 22; 11 20; 19 18; 27 16
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	4 12; 14 16; 24 19
RU Camelop.	7 10.9	+69 51	8.5— 9.8	22 06.5	7 14 29 21
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	3 21; 11 20; 19 18; 27 17
V Carinae	8 26.7	−59 47	7.4— 8.1	6 16.7	6 15; 13 8; 20 1; 26 18

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1920. May							
	h m	° ′		d h	d h	d h	d h	d h			
T Velorum	8 34.4	−47 01	7.6— 8.5	4 15.3	9 19;	19 1;	28 8					
V Velorum	9 19.2	−55 32	7.5— 8.2	4 08.9	7 4;	15 22;	24 16					
Z Leonis	9 46.4	+27 22	7.9— 9.6	59 00.0								
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	6 19;	13 14;	20 8;	27 3				
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	6 2;	12 16;	19 7;	25 21				
S Muscae	12 07.4	−69 36	6.4— 7.3	9 15.8	10 10;	20 2;	29 11					
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	4 1;	12 1;	20 0;	28 0				
T Crucis	15.9	−61 44	6.8— 7.6	6 17.6	2 5;	8 22;	22 10;	29 3				
R Crucis	18.1	−61 04	6.8— 7.9	5 19.8	3 6;	9 2;	20 17;	26 13				
S Crucis	12 48.4	−57 53	6.5— 7.6	4 16.6	1 8;	10 17;	20 2;	29 11				
W Virginis	13 20.9	− 2 52	8.7—10.4	17 06.5	4 3		21 10					
SS Hydrae	25.0	−23 08	7.4— 8.1	8 4.8	1 10;	9 15;	17 20;	26 0				
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	1 2;	8 2;	22 3;	29 4				
ST Virginis	14 22.5	− 0 27	10.3—11.4	0 09.9	9 4;	19 9;	25 14					
V Centauri	25.4	−56 27	6.4— 7.8	5 11.9	3 10;	14 9;	19 21;	30 21				
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	8 16;	16 5;	23 18;	31 7				
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	2 3;	9 13;	24 9;	31 19				
R Triang. Austr.	15 10.8	−66 08	6.7— 7.4	3 09.3	2 3;	8 21;	22 11;	29 5				
S Triang. Austr.	15 52.2	−63 29	6.4— 7.4	6 07.8	8 1;	14 9;	20 17;	27 1				
S Normae	16 10.6	−57 39	6.6— 7.6	9 18.1	6 2;	15 21;	25 15					
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	2 22;	11 19;	20 15;	29 12				
RV Scorpii	16 51.8	−33 27	6.7— 7.4	6 01.5	1 4;	7 6;	19 9;	31 12				
X Sagittarii	17 41.3	−27 48	4.4— 5.0	7 00.3	7 8;	14 8;	21 9;	28 9				
Y Ophiuchi	47.3	− 6 07	6.1— 6.5	17 02.9		14 7		31 10				
W Sagittarii	17 58.6	−29 35	4.3— 5.1	7 14.3	6 3;	13 17;	21 7;	28 22				
Y Sagittarii	18 15.5	−18 54	5.4— 6.2	5 18.6	4 8;	15 21;	21 16;	27 11				
U Sagittarii	26.0	−19 12	6.5— 7.3	6 17.9	3 16;	10 10;	23 22;	30 16				
Y Scuti	32.6	− 8 27	8.7— 9.2	10 08.3	8 1;	18 9;	28 17					
Y Lyrae	34 2	+43 52	11.3—12.3	0 12.1	5 2;	11 3;	23 4;	29 5				
RZ Lyrae	18 39.9	+32 42	9.9—11.2	0 12.3	5 11;	11 14;	23 21;	30 0				
RT Scuti	18 44.1	−10 30	9.1— 9.7	0 11.9	6 13;	12 12;	24 9;	30 8				
κ Pavonis	18 46.6	−67 22	3.8— 5.2	9 02.2	3 2;	12 4;	21 6;	30 8				
U Aquilae	19 24.0	− 7 15	6.2— 6.9	7 00.6	3 2;	10 3;	17 4;	24 4				
XZ Cygni	30.4	+56 10	8.6— 9.3	0 11.2	4 20;	11 20;	18 20;	25 20				
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	6 15;	14 14;	22 14;	30 13				
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	2 20;	10 12;	18 5;	25 21				
η Aquilae	47.4	+ 0 45	3.7— 4.5	7 04.2	3 13;	10 17;	17 21;	25 2				
S Sagittae	51.5	+16 22	5.6— 6.4	8 09.2	7 12;	15 21;	24 6					
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	4 18;	11 2;	17 10;	30 1				
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3	1 23		18 9					
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	5 9;	14 6;	19 17;	27 14				
WY Cygni	52.3	+30 03	9.6—10.4	0 13.5	2 6;	8 23;	22 10;	29 3				
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	4 24;	11 17;	25 3;	31 20				
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4	2 9;	17 2;	31 20					
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	9 0;	16 21;	24 17					
SW Aquarii	10.2	− 0 20	9.9—10.8	0 11.0	4 4;	11 1;	24 20;	31 17				
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	5 15;	10 12;	20 5;	29 23				
Y Lacertae	22 05.2	+50 33	9.1— 9.6	4 07.8	6 13;	15 5;	23 20					
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	5 18;	11 3;	21 20;	27 5				
Z Lacertae	36.9	+56 18	8.2— 9.0	10 21.1	1 15;	12 12;	23 10					
RR Lacertae	37.5	+55 55	8.5— 9.2	6 10.1	7 9;	13 19;	20 5;	26 16				
V Lacertae	44.5	+55 48	8.5— 9.5	4 23.6	2 11;	7 11;	17 10;	27 9				
X Lacertae	22 45.0	+55 54	8.2— 8.6	5 10.7	6 0;	11 11;	22 8;	27 18				
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	4 12;	9 23;	20 20;	31 17				
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	6 22;	13 5;	19 12;	25 20				
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4	9 16		21 19					
V Cephei	23 51.7	+82 38	6.0—7.0	0 23.9	7 19;	14 19;	21 18;	28 18				

Minima of Variable Stars of Short Period.

[Calculated by members of the Class in General Astronomy in Carleton College.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard 6^h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1920							
					May							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8	6 6							
RT Sculptor.	31.5	−26 13	9.6—10.5	0 12.3	8 14;	16 6;	23 23;	31 15				
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	5 21;	13 7;	20 17;	28 4				
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	3 18;	11 5;	18 16;	26 4				
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	1 15;	7 17;	19 23;	26 1				
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	2 9;	9 13;	23 20;	30 23				
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	6 13;	13 10;	20 7;	27 3				
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	4 14;	11 18;	18 22;	26 3				
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	5 8;	14 2;	22 21;	31 16				
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	7 5;	15 4;	23 3;	31 1				
RX Cassiop.	2 58.8	+67 11	8.6— 9.1	32 07.6		10 9						
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	2 20;	8 14;	20 1;	31 12				
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	4 10;	11 5;	24 19;	31 14				
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	2 15;	10 13;	17 10;	26 8				
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	6 1;	14 8;	22 15;	30 23				
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	5 6;	13 4;	21 1;	28 23				
RW Persei	13.3	+42 04	8.8—11.0	13 04.8	1 17		14 21;	28 2				
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	3 16;	13 3;	22 14					
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1	11 6;		23 16					
TT Aurigae	5 02.8	+39 27	7.8— 8.7	0 16.0	6 1;	12 16;	19 9;	26 1				
RY Aurigae	11.5	+38 13	10.7—11.7	2 17.5	6 4;	14 9;	22 13;	30 18				
RZ Aurigae	42.9	+31 40	10.6—13.3	3 00.3	2 22;	8 23;	21 0;	27 0				
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	8 17;	17 0;	26 2					
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	3 16;	14 2;	24 12					
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	8 2;	16 2;	24 3					
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	4 1;	9 19;	21 6;	26 0				
U Columbae	6 11.2	−33 03	9.2—10.0	2 19.2	4 10;	10 0;	21 5;	26 20				
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	3 13;	11 18;	19 23;	28 4				
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	8 11;	16 2;	23 17;	31 8				
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	5 11;	17 16;	29 21					
RU Monoc.	6 49.4	− 7 28	9.8—10.5	0 21.5	2 12;	9 16;	23 0;	31 4				
R Can. Maj.	7 14.9	−16 12	5.8— 6.4	1 03.3	5 23;	12 18;	19 14;	26 9				
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	6 16;	15 23;	25 6					
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	3 2;	9 16;	22 22;	29 12				
TX Gemin.	30.3	+17 8	10.0—11.9	2 19.2	8 10;	16 20;	25 5					
RR Puppis	43.5	−41 08	9.4—10.7	6 10.3	3 16;	10 2;	22 23;	29 9				
V Puppis	7 55.4	−48 58	4.1— 4.8	1 10.9	1 7;	8 14;	23 3;	30 10				
X Carinae	8 29.1	−58 53	7.9— 8.7	0 13.0	5 17;	13 20;	21 23;	30 2				
S Cancri	8 38.2	+19 24	8.2—10	9 11.6	9 18;	19 6;	28 17					
RX Hydrae	9 00.8	− 7 52	9.1—10.5	2 6.8	3 0;	9 20;	23 13;	30 9				
S Velorum	29.4	−44 46	7.8— 9.3	5 22.4	5 0;	10 22;	22 19;	28 17				
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	6 18;	13 12;	20 6;	27 0				
RR Velorum	10 17.8	−41 36	10.0—10.9	1 20.5	2 23;	12 9;	19 19;	27 6				
SS Carinae	10 54.2	−61 23	12.2—12.8	3 07.2	7 0;	13 15;	20 5;	26 19				
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	8 0;	16 19;	25 14					
RW Urs. Maj.	35.4	+52 34	10.3—11.4	7 07.9	1 8;	8 15;	23 7;	30 15				
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	2 7;	9 3;	22 16;	29 11				
RZ Centauri	12 55.6	−64 05	8.5— 8.9	1 21.0	7 12;	15 0;	22 12;	30 1				
RS Can. Ven.	13 06.3	+36 28	7.5—12.5	4 19.1	1 15;	11 5;	20 19;	30 5				
SS Centauri	13 07.2	−63 37	8.8—10.4	2 11.5	8 9;	15 20;	23 6;	30 17				
133926 Hydrae	13 39.0	−26 23	8.6—12.7	2 21.5	1 23;	7 18;	19 8;	30 22				
δ Librae	14 55.6	− 8 07	4.8— 6.2	2 07.9	2 9;	9 8;	23 7;	30 7				

Minima of Variable Stars of Short Period—Continued.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1920 May
	h m	° ′		d h	d h d h d h d h
U Coronae	15 14.1	+32 01	7.6— 8.7	3 10.9	6 1; 12 23; 19 20; 26 18
TW Draconis	32.4	+64 14	7.3— 8.9	2 19.3	6 3; 14 13; 22 23; 31 9
SS Librae	15 43.4	−15 14	9.3—11.5	0 18.4	2 21; 10 13; 18 5; 25 21
SW Ophiuchi	16 11.1	— 6 44	9.2—10.0	2 10.7	3 21; 11 6; 18 14; 25 22
SX Ophiuchi	12.6	— 6 25	10.5—11.2	2 01.5	2 13; 12 19; 21 1; 29 7
R Arae	31.1	−56 48	6.8— 7.9	4 10.2	5 15; 14 11; 23 8
TT Herculis	16 49.9	+17 00	8.9— 9.3	20 18.1	4 10; 15 12; 25 5
TU Herculis	17 09.8	+30 50	9.5—12	2 06.4	2 12; 9 8; 22 22; 29 17
U Ophiuchi	11.5	+ 1 19	6.0— 6.7	0 20.1	3 5; 11 14; 19 23; 28 8
u Herculis	13.6	+33 12	4.6— 5.4	2 01.2	2 11; 8 14; 20 22; 27 2
TX Herculis	15.4	+42 00	8.3— 9.0	1 00.7	5 12; 11 17; 24 1; 30 5
RV Ophiuchi	29.8	+ 7 19	9. —12	3 16.5	3 19; 11 4; 18 13; 25 22
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	1 14; 9 19; 17 23; 26 3
TX Scorpii	48.6	−34 13	7.5— 8.2	0 22.6	7 14; 15 3; 22 16; 30 5
UX Herculis	49.7	+16 57	8.8—10.5	1 13.2	4 1; 11 19; 19 13; 27 7
Z Herculis	53.6	+15 09	7.1— 7.9	3 23.8	4 9; 12 8; 20 8; 28 8
WX Sagittae	53.6	−17 24	9.2—10.8	2 03.1	6 23; 15 11; 24 0
WY Sagittae	17 54.9	−23 1	9.5—10.6	4 16.0	5 12; 14 20; 24 4
SX Draconis	18 03.0	+58 23	9.3—10.5	5 04.1	1 13; 11 21; 22 5
RS Sagittarii	11.0	−34 08	5.9— 6.3	2 10.0	3 23; 11 5; 18 11; 25 17
V Serpentis	11.1	−15 34	9.5—11.1	3 10.9	4 0; 10 22; 24 18; 31 16
RZ Scuti	21.1	— 9 15	7.4— 8.3	15 03.2	8 23; 24 6
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	1 2; 8 6; 22 13; 29 17
RX Herculis	26.0	+12 32	7.0— 7.6	0 21.3	4 5; 11 7; 18 10; 25 13
SX Sagittarii	39.7	−30 36	8.7— 9.8	2 01.8	6 4; 14 11; 22 19; 31 2
RR Draconis	40.8	+62 34	9.3—13	2 19.9	8 20; 17 8; 25 20
RS Scuti	43.7	−10 21	9.3—10.3	0 15.9	1 13; 8 4; 21 11; 28 3
β Lyrae	46.4	+33 15	3.4— 4.1	12 21.8	12 12; 25 10
U Scuti	18 48.9	−12 44	9.1— 9.6	0 22.9	7 23; 15 15; 23 6; 30 21
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.4	6 4; 13 18; 21 8; 28 21
RV Lyrae	12.5	+32 15	11. —12.8	3 14.4	8 3; 15 8; 22 13; 29 17
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	5 21; 14 20; 22 19
U Sagittae	14.4	+19 26	6.5— 9.0	3 09.1	6 12; 13 6; 20 0; 26 18
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	3 1; 10 10; 17 18; 25 3
TT Lyrae	24.3	+41 30	9.4—11.6	5 05.8	4 8; 14 19; 25 7; 30 13
UZ Draconis	26.1	+68 44	9.0— 9.8	1 15.1	4 4; 10 16; 23 17; 30 6
SY Cygni	19 42.7	+32 28	10 —12	6 00.2	2 1; 8 1; 20 2; 26 2
WW Cygni	20 00.6	+41 18	9.3—13.4	3 07.6	7 5; 13 20; 20 12; 27 3
SW Cygni	03.8	+46 01	9. —11.7	4 13.8	1 17; 10 20; 20 0; 29 3
VW Cygni	11.4	+34 12	9.8—11.8	8 10.3	7 4; 15 15; 24 1
RW Capric.	12.2	−17 59	8.8—10.6	3 09.4	7 7; 14 1; 20 20; 27 15
UW Cygni	19.6	+42 55	10.5—13	3 10.8	5 19; 12 17; 19 14; 26 12
V Vulpec.	32.3	+26 15	8.2— 9.8	37 19.0	12 20
W Delphini	33.1	+17 56	9.4—12.1	4 19.4	1 19; 11 9; 21 0; 30 15
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	1 23; 11 4; 20 8; 29 13
Y Cygni	48.1	+34 17	7.1— 7.9	1 12.0	7 4; 14 16; 22 4; 29 16
WZ Cygni	49.3	+38 27	9.9—10.8	0 14.0	1 22; 9 12; 17 3; 24 17
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2	3 22; 14 0; 24 3
VV Cygni	21 02.3	+45 23	12.1—13.8	1 11.4	2 15; 10 1; 17 10; 22 19
AE Cygni	09.0	+30 20	10.8—11.4	0 23.3	4 23; 14 16; 24 9
RY Aquarii	14.8	−11 14	8.8—10.4	1 23.2	2 3; 10 0; 17 21; 25 18
RT Lacertae	21 57.4	+43 24	9.1—10.5	5 01.7	2 18; 12 21; 23 1
UZ Cygni	55.2	+43 52	8.9—11.6	31 07.3	29 2
RW Lacertae	22 40.6	+49 08	10.2—11.2	5 04.4	2 13; 7 17; 18 2; 28 11
TT Androm.	23 08.7	+45 36	11.3—12.6	2 18.4	4 20; 13 3; 21 10; 29 17
Y Piscium	29.3	+ 7 22	9.0—12.0	3 18.3	3 21; 11 10; 18 23; 26 11
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	1 6; 9 12; 17 18; 25 23

NOTES FOR OBSERVERS

Nova Sagittarius No. 6.—Harvard College Observatory Bulletin No. 714, dated March 10, 1920, contains the following announcement:

"A new star, making the sixth in the constellation Sagittarius, has been found by Miss Woods. Its position is R.A. $18^h\ 2^m\ 31^s$, Dec. $-32°\ 29'.1$ (1900).

"Several very faint stars are close to this position and the Nova may be one of these, but at present the identification is uncertain.

"The Nova is not seen on a plate taken on July 24, 1905, which shows stars of about the twelfth magnitude, but appears on a plate taken on July 26, 1905, of magn. 8.8, and on July 27, of magn. 7.1. It is seen on ten plates taken in August of that year, but decreased rapidly in brightness until August 22 when it was magn. 10.0. It is not visible on recent plates. No spectrum of this star was obtained."

Monthly Report of the American Association of Variable Star Observers, January 20 to February 20, 1920

To those of us who have gathered at the Spring Meetings in East Orange, the news of the death of Mr. Edmund Mills, of Jersey City, on January 26, brings a sense of personal loss. His interest in our work was intense and, though unable to take an active part in the actual observing, due to poor health, his enthusiasm was an inspiration to us.

Our unusually good report of this month is especially interesting because of the long interval between maxima of SS Aurigæ 060547; observations with the McCormick 26-inch telescope confirm the fact that there was no rise in January as predicted. The maximum of February 15th was well observed. The present magnitudes of the following novæ may be of interest: Aquilæ No. 3 is of the 8th, Ophiuchi No. 4 of the 10th, Geminorum No. 2 of the 13th, and Persei No. 2 of the 13th.

Two excellent lists from Mr. Lacchini, of Faenza, Italy, are combined in this report. This illustrates the advantages of coöperation between observers in different longitudes, for while we have been enjoying very cloudy conditions, Mr. Lacchini writes that the skies of Italy have been unusually clear. Mr. Peltier is also to be commended for a splendid list with a larger instrument. One of the most encouraging features of the present report is the fact that the observations are so well distributed, and that the important stars in the morning sky have been so well observed; in fact almost one-fourth of the observations were necessarily made after midnight.

It is time to make plans for attending, if possible, the Spring meeting of the Association at the home of Mr. D. B. Pickering, East Orange, N. J., on May 8th.

The following members contributed to this report: Messrs. Chandra, Clement, Eaton, Lacchini, McAteer, Mundt, de Perrot, Peltier, Pickering, Suter, Vrooman, Yalden, and Yont, and Misses Downer, Jenkins, and Young.

Howard O. Eaton,
Recording Secretary.

Variable Star Observations, January 20 to February 20, 1920.

Dec. 0 = 2422293 Jan. 0 = 2422324 Feb. 0 = 2422355

001046 X Androm.

J.D.	Est.	Obs.
242		
2334.6	10.6	M
35.6	10.7	V

001726 T Androm.

2315.6	<10.0	Jd
34.6	<12.6	Do

001755 T Cassiop.

2334.6	7.5	M

001838 R Androm.

2312.6	9.2	V
15.6	8.9	Hu
33.6	9.6	Pt
34.6	9.6	Do
34.6	9.6	M
35.6	9.5	V

***001909* S Ceti**

2281.1	<11.5	Ch

004047 U Cassiop.

2334.6	<12.8	Y

004958 W Cassiop.

2315.6	9.0	Hu
34.6	9.0	M

011208 S Piscium.

2341.5	<13.6	Jk

011712 U Piscium

2321.6	<12.3	Hu

012350 RZ Persei

2334.6	12.7	Y

012502 R Piscium

2341.6	<13.1	Jk

013238 RU Androm.

2334.6	<11.6	M

013338 Y Androm.

2334.6	8.7	M

014958 X Cassiop.

J.D.	Est.	Obs.
242		
2334.6	11.1	M

015354 U Persei

2321.6	10.0	Hu
34.6	10.6	M

021281 Z Cephei

2335.6	10.5	V
41.5	11.1	Do

021403 o Ceti

2317.0	8.3	Mu_3
17.5	8.1	Pt
32.1	8.5	Mu_3
36.5	8.6	Ya
39.1	8.7	Mu_2

022150 RR Persei

2260.6	12.2	Yo
2322.5	8.7	Y
34.6	9.2	

***022813* U Ceti**

2282.2	11.0	Ch

023133 R Trianguli

2260.6	6.1	Yo

024356 W Persei

2333.6	9.6	Pt

030514 U Arietis

2339.5	13.	Y

032043 Y Persei

2337.7	9.8	Pt

041619 T Tauri

2334.5	9.6	M

042209 R Tauri

2334.5	9.3	M
37.7	9.5	Pt

042215 W Tauri

J.D.	Est.	Obs.
242		
2260.6	10.4	Yo
77.6	9.8	
2307.5	10.5	V
21.5	10.4	Yo
34.5	10.8	M
34.6	10.3	Cl
35.7	10.7	V
36.5	10.2	Y
37.7	10.8	Pt

042309 S Tauri

2334.5	<12.3	M

043274 X Camelop.

2336.6	10.3	Y

045307 R Orionis

2336.5	12.6	Y
36.6	12.0	Jk

050003 V Orionis

2336.5	<12.7	Y

***050022* T Leporis**

2321.5	8.7	Yo

050953 R Aurigae

2335.5	10.4	M
35.6	10.1	V
42.5	9.6	Ya

052034 S Aurigae

2339.6	9.0	Ya

***052404* S Orionis**

2334.5	11.6	M
45.6	11.1	E

***053005a* T Orionis**

2334.5	11.0	M

053326 RR Tauri

2345.6	<12.4	E

053531 U Aurigae

J.D.	Est.	Obs.
242		
2322.5	10.7	Y
35.6	9.5	V
36.5	9.2	Y
42.6	9.2	Ya
45.6	9.1	E

054319 SU Tauri

2312.6	9.5	V
21.6	9.5	E
22.5	9.5	Y
34.5	9.3	Cl
35.6	9.4	V
36.5	9.5	E
36.5	9.4	Y
36.6	9.8	Jd
42.8	9.5	E
45.6	9.5	

054615a Z Tauri

2336.5	13.	Y
45.6	13.5	E

054615b RS Tauri

2336.5	9.3	Y
45.6	9.0	E

054615c RU Tauri

2336.5	13.	Y
45.6	13.5	E

054920 U Orionis

2312.6	11.1	Pt
45.6	11.8	E

054974 V Camel.

2334.6	<12.8	Y

055353 Z Aurigae

2321.5		Yo
35.6	10.7	M
42.6	10.9	Ya
45.7	10.2	E

060450 X Aurigae

2337.6	9.2	Pt
39.5	9.1	Ya
45.7	9.5	E

060547 SS Aurigae

J.D.	Est.	Obs.
242		
2291.8	<10.8	Hy
2312.6	<10.8	V
14.5	<12.0	Cl
17.7	<13.0	Hy
18.5	<12.6	Cl
21.6	<13.0	E
22.5	<13.3	Y
22.5	<12.0	Cl
22.7	<10.8	Jd
34.5	<12.4	M
34.5	<12.4	Cl
34.6	<13.3	Y
35.6	<11.4	V
36.5	<13.3	Y
36.6	<12.4	Jd
38.5	<13.0	Jk
39.5	<13.3	E
39.5	<13.3	Y
41.6	<13.0	Jk
42.8	<13.3	E
45.6	<13.0	E

063159 U Lyncis

2334.6	13.	Y

065111 Y Monoc.

2334.6	<13.3	Y

***065208* X Monoc.**

2339.6	8.4	Ya

065355 R Lyncis

2334.6	11.9	Y

070122a R Gemin.

2286.2	7.0	Ch
2321.6	7.9	Hu
35.6	8.7	M
36.6	9.0	Jd
36.6	8.8	E
37.6	8.9	Pt
38.6	8.6	Jd

070122b Z Gemin.

2235.6	<11.6	M
37.6	11.7	Pt

070122c TW Gemin.

2335.6	8.4	M

070310 R Can. Min.

2336.6	9.0	Jd
36.6	9.3	E

To replace pages 242 and 243, in the April, 1920, number of POPULAR ASTRONOMY, for which the wrong matter was printed.

VARIABLE STAR OBSERVATIONS, January 20 to February 20, 1920.

Jan. 0 = 2422324 Feb. 0 = 2422355

001046
X Androm.

J.D.	Est.	Obs.
242		
2365.5	<11.4	V

001629
T Ceti

2307.2	5.1	L
32.2	5.6	
42.2	5.6	

001726
T Androm.

2364.5	13.0	Do

001755
T Cassiop.

2350.4	7.8	L

001838
R Androm.

2293.2	8.2	Ch
2315.2	9.4	
45.5	10.0	Pt
64.6	10.6	Do
65.6	10.1	V

001909
S Ceti

2303.1	<11.5	Ch
43.3	10.2	L
45.5	10.4	Pt

004047
U Cassiop.

2366.5	<12.8	Y

011272
S Cassiop.

2372.5	9.6	Pi

012350
RZ Persei

2352.6	10.7	Y
71.6	10.5	

012502
R Piscium

2362.5	<13.	Y

013238
RU Androm.

2307.1	<11.0	Ch
16.2	<11.0	

013338
Y Androm.

2307.1	9.8	Ch
16.2	8.8	
46.6	8.4	Pt

014958
X Cassiop.

J.D.	Est.	Obs.
242		
2345.6	10.8	Y
66.5	10.8	

021024
R Arietis

2337.3	<12.3	L
47.3	12.3	

021281
Z Cephei

2365.6	<11.5	V
71.5	11.0	Do

021403
o Ceti

2289.1	7.4	Ch
2303.1	7.8	
04.3	7.6	Pe
07.2	7.2	L
12.1	8.0	Ch
14.3	7.8	L
32.3	8.5	
41.6	8.9	Mu
42.2	8.8	L
46.3	8.9	
46.5	9.0	Pt
47.3	9.0	Pe
62.5	8.6	Ya
67.6	9.0	Mu_3

022150
RR Persei

2366.5	9.6	Y

022813
U Ceti

2292.1	<11.0	Ch
2303.1	<11.0	
55.5	9.8	Jk

022980
RR Cephei

2346.3	<13.0	L
71.6	<10.4	Do

023133
R Trianguli

2368.6	10.1	Ya

024356
W Persei

2346.5	9.7	Pt

030514
U Arietis

2366.6	13.	Y

031401
X Ceti

242		
2339.8	10.4	L_2

032043
Y Persei

2346.6	9.6	Pt
68.6	10.0	Ya

042215
W Tauri

2346.5	10.8	Pt
65.6	<11.4	V
66.6	11.5	Y
72.5	11.7	Pi
75.5	11.5	Yo

043065
T Camelop.

2336.2	12.4	L
72.6	9.4	Pi
74.6	9.4	Y

043274
X Camelop.

2349.1	8.8	Y_2
71.6	8.2	Y
72.5	8.5	Pi

044617
V Tauri

2375.6	9.7	Pi

045307
R Orionis

2366.6	12.4	Y

045514
R Leporis

2332.3	6.8	L
37.3	8.3	
42.5	7.2	
43.3	7.5	
45.2	7.1	
47.3	6.9	
50.4	7.2	
62.6	7.8	Ya
74.7	8.4	Pt

050003
V Orionis

2366.6	<12.7	Y

050022
T Leporis

2346.6	8.3	Pt
64.5	9.0	Cl

050953
R Aurigae

J.D.	Est.	Obs.
242		
2352.8	9.5	M
65.6	8.9	Ya
65.6	9.0	V
74.7	9.2	Pt
75.6	9.6	Pi

052034
S Aurigae

2333.5	9.5	L
45.2	9.4	
52.8	9.0	M
64.6	8.8	Ya
72.6	9.1	Pi

052036
W Aurigae

2351.2	10.0	L
52.8	9.8	M

053005
T Orionis

2304.3	10.8	Pe
19.3	10.6	L
32.3	10.2	
45.2	10.8	
46.6	11.0	Pt
50.4	9.9	L

053068
S Camelop.

2372.6	9.0	Pi

053531
U Aurigae

2345.5	9.1	Y
65.6	8.9	V
65.6	8.9	Ya
66.6	9.3	Y
74.7	9.0	Pt

054319
SU Tauri

2314.3	9.5	L
33.3	9.4	
36.3	9.3	
37.3	9.3	
42.3	9.7	
45.2	9.3	
47.3	9.5	
52.5	9.4	E
52.8	9.4	M
53.5	9.5	Cl
62.6	9.4	E
64.5	9.5	Cl
64.8	9.5	E
65.6	9.4	V
66.6	9.4	Y
71.6	9.4	E
75.6	9.4	Pi

054615a
Z Tauri

J.D.	Est.	Obs.
242		
2366.6	<12.8	Y

054615b
RS Tauri

2366.6	9.0	Y

054615c
RU Tauri

2366.6	<12.	Y

054920
U Orionis

2349.5	12.0	Pt
52 8	11.8	M
68.6	<11.5	Pi

054974
V Camelop.

2366.6	<12.8	Y
72.6	<12.6	Pi

055353
Z Aurigae

2352.8	9.7	M
65.6	9.4	Ya
75.6	9.5	Pi

060450
X Aurigae

2349.5	10.0	Pt
50.8	9.3	M
68.7	10.3	Ya
75.6	10.1	Pi

060547
SS Aurigae

2307.3	<12.6	L
14.2	<13.3	
19.3	<12.6	
32.2	<12.6	
33.3	<12.6	
35.3	<12.6	
36.2	<12.6	
37.3	<13.0	
39.3	<13.3	
42.4	<12.6	
43.3	<12.4	
45.2	<13.0	
45.5	<13.3	Y
46.2	<12.4	L
47.2	<12.6	
48.7	<12.6	
49.5	<12.4	Pt
49.5	<12.4	E
50.2	<12.4	L
50.8	<12.4	M
51.2	<12.4	L

VARIABLE STAR OBSERVATIONS, January 20 to February 20, 1920—Continued.

SS Aurigae

J.D.	Est.	Obs.
242		
2351.7	<12.4	L
52.5	<12.4	E
52.6	<13.3	Y
52.8	<12.4	M
52.8	<12.6	Pt
53.5	<12.5	E
53.8	<12.4	M
53.9	<12.6	Pt
54.5	<12.4	E
55.6	<13.0	Jk
55.7	<12.4	E
62.5	<13.3	Y
62.6	<13.3	E
64.5	<12.4	Cl
64.8	<13.3	E
65.6	<11.4	V
65.7	<12.6	Pt
66.5	<13.3	Y
70.7	12.5	E
71.6	10.9	Y
72.5	10.8	Pi
74.6	10.8	Y
74.7	11.1	Pt
75.6	11.5	E
75.6	11.4	Pi

061647
V Aurigae

2352.8	11.2	M

063159
U Lyncis

2366.6	12.9	Y

064932
Nova Gemin. #2

2342.3	<13.0	L

065111
Y Monoc.

2366.6	11.6	Y
68.6	11.7	Pi

065208
X Monoc.

2333.3	8.4	L
46.3	8.2	
66.7	7.9	M
68.6	7.7	Ya

065355
R Lyncis

2366.6	9.8	Y

070122a
R Gemin.

2304.2	7.6	Ch
04.3	7.5	Pe
15.2	7.9	Ch
46.5	9.1	Pt
50.8	9.5	M
68.6	9.8	Pi

070122b
Z Gemin.

242		
2350.8	<11.6	M

070122c
TW Gemin.

2304.3	8.2	Pe
50.8	8.3	M

070310
R Can. Min.

2333.3	9.3	L
42.3	9.3	
50.4	9.0	
68.6	8.7	Pi

071713
V Gemin.

2374.7	8.3	Pt

072708
S Can. Min.

2304.2	<11.0	Ch
15.2	<11.0	

073508
U Can. Min.

2366.6	13.2	Y

073723
S Gemin.

2368.6	<12.4	Pi

074323
T Gemin.

2368.6	<11.5	Pi

074922
U Gemin.

2308.4	<13.3	L
19.3	<11.7	
32.3	<12.3	
33.3	<12.4	
36.3	<12.3	
37.3	<11.7	
39.3	<13.3	
42.3	<13.3	
43.3	<12.4	
45.2	<12.4	
45.6	<13.3	Y
46.3	<12.4	L
47.3	<12.3	
48.7	<11.7	
50.4	<13.3	
50.8	<11.7	M
51.3	<12.3	L
52.6	<13.3	Y
53.8	<12.4	M
55.7	<12.4	E
62.7	10.2	
62.9	10.1	
63.6	10.7	

U Gemin.

242		
2364.8	11.2	E
65.6	<11.7	V
65.7	12.4	Pt
66.5	13.0	Y
66.7	<12.3	M
66.8	13.5	E
68.6	<12.3	Pi
71.6	<13.3	Y
71.6	<13.7	E
74.5	<12.3	Pi
74.6	<13.7	Y

075612
U Puppis

2374.6	12.5	Y

081112
R Cancri

2309.2	9.8	Ch_2
65.7	7.9	Pt
71.6	7.9	Ya
75.6	7.5	Pi

082405
RT Hydrae

2342.4	8.6	L

083019
U Cancri

2365.6	10.6	V

084803
S Hydrae

2310.2	10.2	Ch
65.7	7.5	Pt

085008
T Hydrae

2342.4	9.3	L
65.7	9.9	Pt

085120
T Cancri

2308.4	9.2	L
36.3	9.3	
42.4	9.1	
50.4	9.2	

090151
V Urs. Maj.

2347.3	10.2	Pe

090425
W Cancri

2308.5	10.3	L
42.4	11.5	
50.4	11.7	

093014
X Hydrae

2371.5	11.0	Y

093178
Y Draconis

2352.6	11.1	Y
71.6	11.8	

093934
R Leonis Min.

2333.3	8.1	L
45.3	6.9	
50.8	6.8	M
71.6	6.6	Ya

094211
R Leonis

2347.3	8.7	Pe
50.8	8.4	M
52.8	8.8	Pt
71.6	6.7	Ya
73.7	6.9	Su

103212
U Hydrae

2339.7	5.0	L
51.7	5.3	

103769
R Urs. Maj.

2346.5	7.1	Pt
50.8	7.3	M
72.6	7.5	Pi

104620
V Hydrae

2339.7	6.3	L
51.7	6.7	

104814
W Leonis

2352.6	10.3	Y
53.8	9.6	M
71.6	10.3	Y

110506
S Leonis

2374.6	11.3	Y

121418
R Corvi

2346.7	<11.7	L
53.8	<11.2	M

122001
SS Virginis

2339.7	6.1	L
51.7	7.6	

122532
T Can. Ven.

2353.8	11.6	M

122803
Y Virginis

242		
2339.7	<12.0	L

123160
T Urs. Maj.

2347.3	11.2	Pe
50.8	10.6	M
55.6	11.7	Jk
65.7	12.1	Pt
75.5	<11.7	Pi

123307
R Virginis

2320.7	7.1	L
39.7	6.2	
49.8	6.9	Pt
51.7	7.0	L

123459
RS Urs. Maj.

2365.7	11.6	Pt
75.5	10.9	Pi

123961
S Urs. Maj.

2342.4	11.8	L
47.3	11.1	Pe
50.4	12.0	L
50.8	11.2	M
55.5	11.4	Jk
65.7	11.3	Pt
74.5	10.9	Pi

124606
U Virginis

2349.8	11.6	Pt

132422
R Hydrae

2349.8	7.3	Pt
46.7	7.2	L

132706
S Virginis

2349.8	7.5	Pt

134440
R Can. Ven.

2350.8	11.5	M
66.6	11.7	Y

135908
RR Virginis

2353.8	<12.1	M

140113
Z Bootis

2353.8	9.6	M

Variable Star Observations, January 20 to February 20, 1920—Continued.

072708
S Can. Min.

J.D.	Est.	Obs.
242		
2282.2	9.7	Ch
2334.5	9.9	Cl

073508
U Can. Min.

2354.6	13.1	Y

074323
T Gemin.

2335.6	<11.5	V

074922
U Gemin.

2291.8	<12.3	Hy
2314.5	<12.5	Cl
17.7	<13.3	Hy
21.5	<12.5	Yo
22.5	<11.9	Cl
34.5	<12.3	M
34.6	<13.3	Y
35.6	<11.7	V
38.6	<13.3	Jk
39.7	<13.3	Hy
39.7	<13.7	E
42.8	<13.3	E
45.6	<13.3	E

081112
R Cancri

2334.6	9.7	Cl
37.7	8.9	Pt
39.6	8.7	Ya

083019
U Cancri

2335.6	10.5	V

084803
S Hydrae

2335.7	8.2	Pt

085008
T Hydrae

2335.7	9.0	Pt
36.6	9.0	E
36.6	9.2	Jd

090425
W Cancri

2335.6	<11.7	V

093178
Y Draconis

2334.6	10.8	Y

093934
R Leonis Min.

2435.7	7.9	Pt
39.6	7.5	Ya

094211
R Leonis

J.D.	Est.	Obs.
242		
2335.6	9.5	Pt
36.6	9.2	Jd
36.6	9.3	E

103769
R Ursae Maj.

2317.6	9.5	Pt
25.8	8.5	M

123160
T Ursae Maj.

2325.8	9.3	M
35.7	10.0	Pt
38.6	10.6	Jk
39.5	11.0	Do

123961
S Urs. Maj.

2325.8	11.0	M
35.7	12.0	Pt
38.6	12.1	Jk
39.5	12.0	Do

134440
R Canum Ven.

2325.8	<11.2	M

142539
V Bootis

2325.8	8.5	M

153378
S Ursae Min.

2307.5	8.8	V

154428
R Cor. Bor.

7.9	6.1	Pt
25.8	6.2	M

163137
W Herculis

2322.5	8.5	Y

163172
R Ursae Min.

2334.5	11.6	Cl

163266
R Draconis

2322.5	12.5	Y
41.5	11.8	Jk

165631
RV Herculis

2338.9	12.0	E

175458a
T Draconis

2341.5	12.0	Jk

175458b
UY Draconis

2341.5	10.8	Jk

180565
W Draconis

J.D.	Est.	Obs.
242		
2339.6	<13	Jk

180911
Nova Ophiuch No. 4

2307.5	8.9	V

184205
R Scuti

2312.5	5.5	Pt

184300
Nova Aquilae No. 3

2280.2	>8.0	Ch
12.5	7.7	P

190925
S Lyrae

2336.5	<11.6	Do

191637
U Lyrae

2337.5	11.1	Pt

193449
R Cygni

2267.1	10.5	Ch
84.2	10.9	Ch
2307.5	9.8	V
17.5	9.5	Pt
35.5	8.7	V

194048
RT Cygni

2284.2	9.2	Ch
2335.5	7.9	V
37.6	7.5	Pt

194348
TU Cygni

2335.5	<11.2	V

194632
χ Cygni

2336.5	<12.4	Do

195849
Z Cygn

2317.5	12.6	Pt

200647
SV Cygni

2291.8	7.7	Hy
2313.6	8.4	Ya

201130
SX Cygni

2322.5	8.3	Y
34.5	9.5	Y

201647
U Cygni

J.D.	Est.	Obs.
242		
2291.8	7.0	Hy
2317.5	7.8	Pt
25.7	8.6	Jd
34.5	7.8	Ya

202946
SZ Cygni

2313.6	9.6	Ya

202954
ST Cygni

2334.5	13.3	Y

203226
V Vulpec.

2317.5	9.1	Pt

203816
S Delphini

2307.5	10.4	V
34.5	10.3	Cl

205923
R Vulpec.

2317.5	9.3	Pt

210129
TW Cygni

2322.5	12.5	Y
34.5	12.4	Y

210868
T Cephei

2315.6	7.0	Hu
17.6	8.1	Pt
34.6	7.7	Ya

211614
X Pegasi

1324.5	11.0	Y

213678
S Cephei

2315.6	9.0	Hu

213753
RU Cygni

2315.6	8.9	Ya

213843
SS Cygni

2280.2	< 9.6	Ch
91.8	11.7	Hy
2307.5	<11.3	V
12.6	11.9	Pt
14.5	12.1	Cl
17.5	12.0	Pt
18.5	12.1	Cl
21.5	11.9	Pt
21.6	11.5	E
22.5	12.0	Cl
22.5	11.6	Y

SS Cygni

J.D.	Est.	Obs.
242		
2325.5	<11.3	Y
25.6	<10.9	Jd
26.5	<11.3	Y
29.5	11.8	Cl
29.5	11.9	Pt
33.6	8.5	
34.5	8.5	Y
34.5	8.3	M
34.5	8.3	Cl
34.6	8.2	Do
35.5	8.4	M
35.5	8.7	V
35.6	8.5	Pt
36.5	8.4	
37.5	8.5	
39.5	8.6	E
41.5	8.4	Jk

225914
RW Pegasi

2334.5	10.2	Y
35.5	10.1	V

230110
R Pegasi

2334.5	9.0	Y
37.5	8.4	Pt

230759
V Cassiop.

2315.6	11.2	Hu
17.6	11.3	Pt

231425
W Pegasi

2315.6	10.0	Hu

232848
Z Androm.

2334.6	9.0	Do

233335
ST Androm.

2315.6	9.0	Hu
34.6	9.2	Do
37.7	9.1	Pt

233815
R Aquarii

2337.5	7.3	Pt

235855
Y Cassiop

2335.6	<11.0	

235939
SV Androm.

2315.6	8.1	Hu
34.5	8.5	Y
37.7	8.6	Pt
39.6	9.4	Jk

No. of Observations: 275; No. of Stars Observed: 114; No. of Observers: 15.

VARIABLE STAR OBSERVATIONS, January 20 to February 20, 1920—Continued.

141567
U Urs. Min.

J.D.	Est.	Obs.
242		
2375.6	11.4	Pi

141954
S Bootis

2320.7	<12.0	L
42.5	12.5	

142539
V Bootis

2320.7	8.3	L
42.5	7.8	
49.8	7.4	Pt
52.8	7.8	M

143227
R Bootis

2349.9	7.9	Pt
73.7	6.8	Su

144918
U Bootis

2354.9	11.2	M

150018
RT Librae

2354.9	9.2	E

150519
T Librae

2354.9	12.4	E

150605
Y Librae

2354.9	12.5	E

151520
S Librae

2346.7	9.8	L
54.9	9.4	E

151714
S Serpentis

2346.7	<12.1	L
54.9	13.3	E

151731
S Cor. Bor.

2349.9	7.6	Pt
54.9	7.9	M
54.9	7.3	E

151822
RS Librae

2346.7	9.5	L
54.9	9.9	E

153620
U Librae

2354.9	11.1	E

154428
R Cor. Bor.

J.D.	Est.	Obs.
242		
2320.7	6.1	L
39.7	7.1	
46.7	6.6	
48.7	6.4	
49.9	5.9	Pt
50.8	6.7	Su
51.7	6.3	L
52.8	6.0	Pt
53.8	6.0	M
53.9	6.0	Pt
65.8	6.0	
73.7	6.9	Su
74.9	6.0	Pt

154536
X Cor. Bor.

2353.8	9.8	M

154615
R Serpentis

2349.9	8.9	Pt
53.9	8.6	M

154639
V Cor. Bor.

2353.8	8.8	M

155229
Z Cor. Bor.

2354.9	10.8	M

160021
Z Scorpii

2351.7	10.3	L

160118
R Herculis

2354.9	<12.4	M

160210
U Serpentis

2349.9	8.1	Pt
54.9	8.0	E

160625
RU Herculis

2354.9	<11.7	M

161122a
R Scorpii

2349.9	11.5	Pt

161607
W Ophiuchi

2348.7	<12.0	L

162119
V Herculis

2349.9	10.6	Pt
53.9	10.3	M

162807
SS Herculis

242		
2354.9	9.4	M

163137
W Herculis

2349.9	8.3	Pt
53.9	8.5	M

163172
R Urs. Min.

2353.9	9.7	M

163266
R Draconis

2353.9	11.7	M
55.5	11.0	Jk

164055
S Draconis

2353.9	8.8	M

165631
RV Herculis

2349.9	10.8	Pt
53.9	11.0	M

170627
RT Herculis

2352.9	<12.8	E

171401
Z Ophiuchi

2349.9	8.1	Pt
52.9	8.4	E

171723
RS Herculis

2349.9	9.4	Pt
52.9	8.9	E

172809
RU Ophiuchi

2352.9	12.6	E
54.9	<12.6	M

174406
RS Ophiuchi

2352.9	11.5	E

175111
RT Ophiuchi

2352.9	<12.4	E

175519
RY Herculis

2352.9	13.0	E

180531
T Herculis

2305.2	12.4	L
08.1	<11.0	Ch
14.2	11.2	L
48.7	8.2	
52.9	7.2	E
53.9	8.6	M

180911
Nova Ophiu. #4

J.D.	Est.	Obs.
242		
2305.2	8.7	L
07.2	8.6	
08.2	8.4	
09.2	8.7	
11.2	8.7	
14.2	8.7	
39.7	9.0	
46.7	9.4	
48.7	9.6	
51.7	9.7	
53.9	10.2	Pt

181103
RY Ophiuchi

2352.9	9.0	E

181136
W Lyrae

2339.2	10.3	L
49.9	10.6	Pt
54.9	10.6	M

182224
SV Herculis

2307.2	12.5	L
48.7	<12.5	
52.9	<13.3	E

182306
T Serpentis

2352.9	<11.8	E

183149
SV Draconis

2362.9	<12.8	E

183225
RZ Herculis

2362.9	<12.2	E

183308
X Ophiuchi

2351.7	8.6	L
62.9	8.5	E

184134
RY Lyrae

2354.9	<13.3	E

184205
R Scuti

2307.2	6.1	L
11.2	5.9	
46.7	5.5	
49.9	5.4	Pt
51.7	5.5	L
53.9	5.4	Pt

184243
RW Lyrae

2354.9	12.1	E

184300
Nova Aquilae #3

J.D.	Est.	Obs.
242		
2305.2	7.8	L
49.9	7.9	Pt
51.7	8.0	L
53.9	7.9	Pt

185032
RX Lyrae

2354.9	<13.0	E

185512
ST Sagittarii

2362.9	<9.6	E

185634
Z Lyrae

2362.9	12.1	E

185737
RT Lyrae

2362.9	<13.0	E

190925
S Lyrae

2348.7	12.8	L

191637
U Lyrae

2349.9	10.8	Pt

193449
R Cygni

2292.1	10.4	Ch
99.6	9.9	
2310.1	9.5	
16.1	8.9	
74.9	9.0	Pt

194048
RT Cygni

2303.1	8.5	Ch
10.1	8.2	
16.1	7.8	
74.9	8.5	Pt

194632
χ Cygni

2353.9	12.0	Pt

200212
SY Aquilae

2307.2	<12.0	L
39.2	<10.8	

200647
SV Cygni

2365.9	8.6	M

VARIABLE STAR OBSERVATIONS, January 20 to February 20, 1920—Continued.

200938 RS Cygni

J.D.	Est.	Obs.
242		
2308.2	7.7	L
32.2	9.1	
42.3	8.9	
51.3	9.0	
53.9	8.8	Pt

201008 R Delphini

J.D.	Est.	Obs.
2339.2	10.7	L

201121 RT Capric.

J.D.	Est.	Obs.
2305.2	7.4	L

201647 U Cygni

J.D.	Est.	Obs.
2345.5	9.0	Pt
65.9	7.1	M

202946 SZ Cygni

J.D.	Est.	Obs.
2353.5	9.5	Cl

204405 T Aquarii

J.D.	Est.	Obs.
2292.1	<11.0	Ch
2303.1	<11.0	
13.1	11.0	

210868 T Cephei

J.D.	Est.	Obs.
242		
2319.3	7.1	L
32.3	7.5	
45.3	6.9	
45.5	8.0	Pt
65.6	7.4	Ya

213244 W Cygni

J.D.	Est.	Obs.
2307.3	5.6	L
32.2	6.0	
38.3	5.9	L_3
46.3	5.8	L_2

213843 SS Cygni

J.D.	Est.	Obs.
2303.1	<11.0	Ch
07.3	11.8	L
08.4	12.0	
09.2	12.0	
14.3	12.1	
16.1	<11.0	Ch
19.3	11.7	L
32.2	8.5	
33.3	8.5	
35.3	8.3	
36.3	8.3	
37.3	8.6	
39.3	8.7	
42.3	9.0	

SS Cygni

J.D.	Est.	Obs.
242		
2343.2	9.2	L
45.2	9.7	
45.5	9.8	Pt
45.6	9.5	Y
46.4	9.9	L
46.5	10.2	Pt
47.2	10.2	L
48.7	11.2	
49.5	11.4	Pt
51.2	11.3	L
53.5	11.6	Pt
53.5	11.5	Cl
55.5	<11.3	Jk
64.5	11.8	Cl
64.5	12.0	Do
74.6	11.7	Y

215934 RT Pegasi

J.D.	Est.	Obs.
2345.6	9.4	Y

220412 T Pegasi

J.D.	Est.	Obs.
2339.3	<12.7	L

222439 S Lacertae

J.D.	Est.	Obs.
2308.4	12.4	L
43.2	<12.4	L

223841 R Lacertae

J.D.	Est.	Obs.
242		
2308.4	9.7	L
32.3	9.2	L
43.3	9.6	L

225914 RW Pegasi

J.D.	Est.	Obs.
2353.5	9.5	Cl
55.5	10.3	Jk
62.5	10.1	Y

230110 R Pegasi

J.D.	Est.	Obs.
2345.5	8.2	Pt
55.5	8.0	Jk

230759 V Cassiop.

J.D.	Est.	Obs.
2345.5	10.1	Pt

231425 W Pegasi

J.D.	Est.	Obs.
2308.4	10.7	L
35.3	10.3	L_3
42.3	10.4	L
51.3	10.2	

231508 S Pegasi

J.D.	Est.	Obs.
2345.5	10.3	Pt

232848 Z Androm.

J.D.	Est.	Obs.
242		
2364.5	9.4	Do

233335 ST Androm.

J.D.	Est.	Obs.
2305.2	9.8	Ch
15.2	9.5	Ch
46.5	8.9	Pt
64.5	9.4	Do

233815 R Aquarli

J.D.	Est.	Obs.
2292.1	6.7	Ch
2303.1	6.9	Ch
14.1	6.9	Ch
45.5	7.9	Pt

235209 V Ceti

J.D.	Est.	Obs.
2309.3	<11.7	L
39.3	<12.7	L

235939 SV Adrom.

J.D.	Est.	Obs.
2345.6	9.0	Y
46.5	8.0	Pt
55.6	10.2	Jk

No. of Observations: 541. No. of Stars Observed: 180. No. of Observers: 16.

COMET AND ASTEROID NOTES.

A New Comet *g* 1919 (Skjellerup).—In the February number of *The Observatory* it is stated that a new comet was discovered by Mr. J. F. Skjellerup at the Cape on December 18. It was observed at the Cape Observatory by Mr. Woodgate. Dr. Halm has computed the following provisional elements:

$$T = 1920 \text{ Jan. } 2.2674 \text{ G.M.T.}$$
$$\omega = 276^\circ\ 35'$$
$$\Omega = 315\ \ 36$$
$$i = 123\ \ 10$$
$$\log q = 9.47376$$

According to these elements the comet should be now visible in the northern hemisphere. It seems strange that no announcement of it should have been made to observers in the United States.

The accompanying diagram, prepared with the aid of Dr. Halm's preliminary elements, shows the relation of the comet's orbit to that of the earth. When discovered, the comet was at about its closest approach to the earth. It had al-

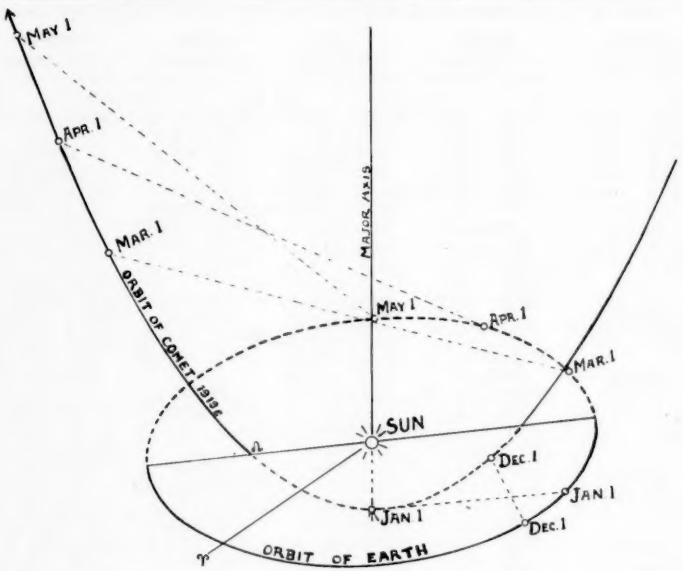


DIAGRAM OF THE ORBIT OF COMET 1919 *g* (SKJELLERUP).
The date Dec. 1 should be Dec. 18.

ready passed its descending node and was soon after that in conjunction with the sun. In the latter part of January it passed behind the sun, emerging in February, but at such a great distance from the earth that it may not have been recovered by the southern observers. There is an error in the diagram, which was discovered after the block had been made for printing. The date Dec. 1 in both places where it occurs in the diagram should be Dec. 18.

There is no statement in *The Observatory* as to the brightness of the comet. Unless it was very bright there is little hope of its being picked up again, although its position, except for distance, will be quite favorable to northern observers during April.

The following ephemeris was computed from Dr. Halm's elements, by Messrs. Wilson and Gingrich. It is barely possible that the comet may be picked up with the aid of one of the great telescopes.

EPHEMERIS OF COMET 1919 *g*.

G.M.T. 1920		R.A. h	m	s	Dec. °	′	log *r*	log Δ	Br.
April	4.5	20	29	42	+18	53	0.3025	0.3423	0.003
	8.5		27	13	20	34	0.3159	0.3424	
	12.5		24	14	22	15	0.3288	0.3425	
	16.5		20	44	23	55	0.3411	0.3426	0.003
	20.5		16	40	25	35	0.3530	0.3427	
	24.5		11	59	27	13	0.3644	0.3430	
	28.5	20	06	42	+28	49	0.3756	0.3436	0.002

Brightness Dec. 18, 1919 = 1.00

The Planet Comas Solá.—In Circular 301 of the Marseilles Observatory are given the following elements of the asteroid recently discovered by Comas Solá, of Barcelona. The elements were computed by M. Henri Blondel from observations on the dates January 18, 30 and February 12. This is the first instance in which we have seen the elements of a planet given in hundredths of a right angle.

ELEMENTS

Epoch 1920 January 30.5 G.M.T., Mean Equinox 1920.0

Hundredths of Right Angle.		Degrees (sexagesimal)		
M =	392.9128	353°	37′	17″.3
ω =	209.2937	188	21	51.5
☊ =	332.9994	299	41	58.2
i =	23.7708	21	23	37.5
ϕ =	4.7490	4	16	26.6
μ =	0.2468988	799″.952		
log a =	0.431295			

The period of the planet is very near 4.50 years. At its next opposition, in 1921, it will be far south, and will not be observable in our latitude until August 1922. It is important therefore to follow it as long as possible this year.

An ephemeris from these elements is given in Circular 305 of the Marseilles Observatory. The following is the portion for April and May:

EPHEMERIS OF COMAS SOLA'S PLANET.

G.M.T. 1920		R.A. h	m	s	Dec. °	′	log Δ	log r	Mag.
April	2.5	7	32	00	+14	24.1	0.3292	0.3980	11.8
	4.5		33	23		14 13.4			
	6.5		34	50		14 02.7			
	8.5		36	22		13 52.0	0.3447	0.3982	
	10.5		37	59		13 41.2			
	12.5		39	40		13 30.3			
	14.5		41	25		13 19.4	0.3597	0.3983	
	16.5		43	14		13 08.4			
	18.5		45	08		12 57.3			
	20.5		47	06		12 46.1	0.3742	0.3985	12.0
	22.5		49	07		12 34.8			
	24.5		51	11		12 23.4			
	26.5		53	18		12 11.8	0.3881	0.3987	
	28.5		55	29		12 00.1			
	30.5	7	57	43		11 48.2			
May	2.5	8	00	00		11 36.2	0.4015	0.3989	
	4.5	8	02	19		11 24.0			
	6.5		04	41		11 11.6			
	8.5		07	06		10 59.1	0.4142	0.3992	12.3
	10.5		09	33		10 46.4			
	12.5		12	03		10 33.5			
	14.5		14	35		10 20.3	0.4263	0.3992	
	16.5		17	09		10 06.9			
	18.5		19	45		9 53.4			
	20.5		22	23		9 39.7	0.4377	0.3997	12.3
	22.5		25	03		9 25.8			
	24.5		27	45		9 11.6			
	26.5		30	28		8 57.2	0.4485	0.4000	12.5
	28.5		33	13		8 42.5			
	30.5		35	59		8 27.6			
June	1.5	8	38	47	+ 8	12.5	0.4587	0.4003	12.5

Ephemeris of Nestor (659).—The following ephemeris of the asteroid Nestor (659), one of the Trojan Group with a period nearly equal to that of Jupiter, has been computed by Mr. F. E. Seagrave. The asteroid will be at opposition April 3, 1920.

Gr. Midnight 1920		α			δ			log r	log Δ
		h	m	s	°	′	″		
March	19	12	58	29	−8	37	33	0.73988	0.65677
	23	12	56	39	8	28	26	0.73972	0.65485
	27	12	54	45	8	18	46	0.73950	0.65331
	31	12	52	48	8	08	35	0.73930	0.65225
April	4	12	50	50	7	58	10	0.73912	0.65169
	8	12	48	52	7	47	37	0.73890	0.65156
	12	12	46	56	7	36	54	0.73872	0.65196
	16	12	45	04	7	26	19	0.73852	0.65279
	20	12	43	14	7	15	54	0.73830	0.65407
	24	12	41	30	−7	05	53	0.73810	0.65582

Opposition April 1.

COMMUNICATIONS

The Aurora of March 22, 1920.—In the early evening of March 22 there took place the most spectacular display of aurora borealis that has occurred so far this year. When first seen at about 7:30 P. M. a wide ribbon-like, waving curtain of green light extended in a huge arc across the northern sky, well over the constellation Cassiopeia. From this arch pulsating streamers shot towards the zenith and seemed to converge in a point directly overhead. At times the edges of some of the streamers and of the curtain bands would show a decided crimson tint, which would waver and flare like the flame of a dying fire. Maximum activity seemed to be reached at about 8:00 P. M. and then the display began to die down. Soon, however, the height and brilliancy of the streamers began to increase once more and by 8:05 P. M. it became evident that another outburst was about to take place, which would equal if not surpass the first.

The phenomena this time took the form of a wide wavy curtain of light, ever shifting and weaving in and out, over which rosy-pink patches of light traveled slowly toward the east and faded out, only to begin again at the north and repeat the performance. At 8:10 P. M. the magnetic needle showed marked perturbation, swinging toward the east five or ten degrees, and once showing a shift of twenty degrees. During some of the more brilliant flashes a distinct snapping or crackling sound could be heard. These manifestations continued for nearly ten minutes, after which their intensity rapidly diminished, and by 8:20 P. M. only a few pale green wisps of light remained quivering in the north. The aurora did not cease, however, but with occasional fits and starts continued until the early morning of March 23. One of the features of this exhibit was the occurrence of several intensely bright green areas of light almost sixty degrees from the horizon, and of a brightness equal to that of the full moon.

On March 23 I observed the sun and noted a row of five large spots and several smaller ones. This is a larger number of spots than I have seen on the sun lately. This was the best auroral display we have had here in two or three years, in fact I do not recall having seen an aurora which was as bright as this one in a long time.

"I love to watch the Northern lights
With rushing splendors fly,
Like living things, with flaming wings
Wide o'er the wondrous sky".

LEWIS J. BOSS.

North Scituate, R. I., March 23, 1920.

GENERAL NOTES.

American Astronomical Society.—The next meeting of the American Astronomical Society will be held at Smith College Observatory, Northampton, Massachusetts, beginning September 1, 1920. The society will also visit the observatory at Mt. Holyoke College.

A New Astronomical Periodical.—A new astronomical periodical has been launched in Copenhagen, Denmark. It is the "Nordisk Astronomisk Tidsskrift" edited by Julie M. Vinter-Hansen, Copenhagen, J. Fr. Schroeter, Kristiana, and Walter Gyllenberg, Lund. The new magazine should do much to further popular interest in astronomy in Denmark, Norway and Sweden.

Secular Parallax of the Stars.—This is the gradual apparent displacement of the stars due to the movement of the solar system through space. Professor Kapteyn, director of the Groningen Observatory, has found that, for stars of all spectral classes together, the mean secular parallax as dependent upon galactic latitude *(b)* and apparent visual magnitude *(m)* is capable of accurate representation by the formula

$$\log (\text{secular parallax}) = -0.428 - 0.096 \cos 2b - 0.1373\, m.$$

Assuming a velocity of 195 km per second, the secular parallaxes can be converted into annual parallaxes by multiplying by 0.243.

Singular Dates.—In *L'Astronomie* for December 1919 Mr. E. de Perrot, of Yverdon, Switzerland, points out a number of dates which are interesting from the peculiar combinations of digits which occur when month, day and year are expressed numerically. The note was suggested by the combination for November 19, 1919, namely 19 9 1919. This is a little more striking if the month number is given first. The following array of such dates have occurred in the present millenium:

1 11 1111,	3 13 1313,	5 15 1515,	7 17 1717,
2 12 1212,	4 14 1414,	6 16 1616,	8 18 1818,
			9 19 1919.

We might add to these 11 11 1111 and 12 12 1212.

In the next millenium there will be

2 20 2020, 10 20 2020, 1 21 2121, 2 22 2222.

It may add to the interest of the date 9 19 1919 that the day following it was 2422222 of the Julian Calendar.

The Julian day 2222222 occurred in the year 1371.

Telephoning by Means of Invisible Light.—Interesting work has been done by Messrs J. Herbert-Stevens and A. Larigaldie, of France, in the direction of wireless telephony employing infra-red beams of light. The source of light used for infra-red signalling is an arc searchlight or an electric lamp, the light being passed through an absorbing screen of black manganese-dioxide glass or of colored gelatine or cellophane. The receiver consists of a parabolic mirror, with a special thermopile at its focus. The use of this thermopile in conjunction with a valve amplifier has enabled communication to be established at distances of over 15 miles. The thermopile is so constructed that its inertia is almost zero. A metal plate 0.01 mm thick is sealed by autogenous fusion on the point of a crystal of great thermo-electric power. The best results have been obtained with platinum and a crystal of tellurium. A glass cell is used to contain the two and is provided with a fluorite window. The thermo-electric couple is connected to a vacuum-tube amplifier, the current being broken by a tikker at a musical frequency, and a potentiometer is included in the circuit to eliminate any currents due to local conditions causing temperature variation of the junctions. A complete description of this system of telephony, together with photographs and diagrams, appears in the next issue of this journal. (*Scientific American*, February 28, 1920.)

Observation of Planetary Detail.—Some interesting experiments on the ability of various persons to observe different kinds of planetary detail have been carried on at the University of Glasgow by Mr. T. L. MacDonald. Six students, having no previous knowledge of the Martian problem, were invited to copy a drawing of Mars by Antoniadi, as well as two other pictures, one being a photograph of the moon (for canal-like markings). No suggestion was made to them either as to what would be visible or the manner of drawing it. An examination of the results brings out the curious fact that practically without exception the observer who excelled most in noting either canals, lakes or gradations of shading, either did not excell or actually fell below the average in respect to the others. Thus the student who saw the most canals saw the smallest number of shadings and nearly the smallest number of lakes, etc. Moreover, the distinguishing characteristic of each observer remains through all the sets of drawings with remarkable persistency. Mr. MacDonald formulates tentatively the rule that the work of all planetary observers may be classed according to sensitiveness to lines, spots and shadings; of which excellence in one is exclusive of excellence in the remainder. Thus it may be possible to classify observers by three coefficients, for canal, spot and shade sensitiveness, and correct their work in planetary drawings accordingly. (*Scientific American*, March 20, 1920.)

Signaling to Mars.—Every little while we see something in the daily newspapers to the effect that some astronomer is seriously proposing to attempt to signal to Mars, the planet which approaches nearest to the earth. It is doubtful whether any reputable astronomer has ever made this proposal other than in a humorous vein. The thought of exchanging signals with our nearest neighbors in space is exceedingly interesting, but if indeed gigantic signals could be produced so that they could be seen distinctly by the inhabitants of the other planet, the difficulty of acquainting them with the code of signals would seem to be insuperable. In the *Scientific American* for March 20, 1920, however, is an article

by H. W. and C. Wells Nieman in which the attempt is made to explain "A system for opening communication despite the absence of any common basis of language." The title of the article is "What Shall we Say to Mars?"

The Ultra-Neptunian Planets.— Although the best trained astronomers are unable to determine whether there is an ultra-Neptunian planet or not, one who is not an astronomer is able to give the periods of two such planets; witness the following communication:

6119 South Lincoln Street, Chicago.
March the seventh, Nineteen-twenty.

While scientific men are pondering the possibility of more planets in our solar system beyond Neptune, kindly allow me to offer the following information:

There are two such planets, at present in the twenty-third and twenty-seventh degrees, respectively, of the astrologic sign Taurus, and separating from a conjunction. I specify, "the astrologic sign Taurus" because I am not a student of astronomy, yet understand that there is a considerable difference between the astrologic signs and the astronomic constellations of the same name.

In so far as I understand, Neptune's period has been estimated variously; therefore, allow me the liberty of stating the periods of these three planets definitely:

Neptune, 149 years; Styxia, 228 years; and Janus, 426 years.

Although I am forwarding this same information to others who will be interested, you will oblige me greatly by acknowledging receipt of same.

P. W. GIFFORD, Co-ologist.
(Humanitarian Harmonist.)

Above information ascertained by means of Co-ologic
Astrology, March one, two, and four, nineteen-twenty.

The Book of the Damned,—by Charles Fort. Boni and Liveright, New York, 1919.

A strange book—stranger than its title. A collection of accounts of strange happenings, which have been recorded, but which have not been admitted to standing as scientific data. Damned, in the author's sense, means excluded. "But," he says, "by the excluded I mean that which will some day be the excluding."

"About one hundred years ago, if anyone was so credulous as to think that stones had ever fallen from the sky, he was reasoned with:

"In the first place there are no stones in the sky. Therefore no stones can fall from the sky."

Today "meteorites, data of which were once of the damned, have been admitted, but the common impression of them is only a retreat of attempted exclusion; that only two kinds of substance fall from the sky: metallic and stony; that the metallic objects are of iron and nickel——"

The book, with hundreds of strange accounts, believable and unbelievable, is very readable and suggestive.

Atlas Céleste.— A second edition of the "Petit Atlas Céleste" by G. Bigourdan of the Paris Bureau of Longitudes has been issued in 1920. It is a small atlas with 53 pages of explanatory matter and 5 maps of the constellations. Price 2 francs. It can be obtained from Gauthier-Villars & Co., 55, Quai des Grands-Augustins, Paris, France.

THE DARK STAR

To the Companion of Algol

(Algol, a well-known star in the constellation Perseus, was so named by the Arabs because of its sudden fluctuations in brilliancy. Modern scientists and the spectroscope have shown that the cause of these fluctuations is a partial eclipse of Algol by a companion dark body revolving about it. The discovery of this dark star proves what previously had been but a theory,—that space swarms with countless myriads of these dead suns.)

Thou dark companion of a radiant orb,
Betrayer of that shrouded swarm that sweeps
Amid their brothers of a later day—
Do your warm fires still obstinately flame
Beneath their veil of suffocating cloud;
Or, like the Moon, are you at length resigned
To shadowed fate of cold and crusted age?
When yet the fire of Vega was unlit,
And Sirius still was but a fledgling sun,
Your blue-white rays cut through the dark abyss,
And burned the message of your youthful pride
Down all the aisles of that forgotten night.
Then in the autumn of your flaming course,
Like swift Arcturus and Capella now,
You shed your more mature and softer glow
Amid the galaxy of rushing suns.
Your youth had passed, but still your spirit held
Against the ever gnawing chill of space
That pressed you closer as the ages fled.
By slow degrees the vapours choked you down,
Until your spirit wearied of the strife.
The night of death closed in and crushed you close;
Its icy fingers gripping at your heart,
Where the hot fires still sought in vain to halt
The ordered march of slow relentless Fate.
Perhaps some sullen flames do battle yet,
With memories of the past to spur them on—
But what avail? Condemned to living death
You swing amid the throng of splendid stars
Who challenge Time as boldly as did you.
Your road is theirs, their glory is but brief
Upon the pages of Eternity.
In dim procession they will go to join
That cold unnumbered host who fling unseen
Through the vast reaches of sidereal space,
Recruiting endlessly their teeming ranks,
From the dull spectres of forgotten suns.

BEN RAY REDMAN.